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A GUIDE TO NUCLEAR WEAPONS PHENOMENA AND EFFECTS LITERATURE

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Technical Report

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SECTION 1

INTRODUCTION

This Guide is an overview of the basic and most significant literature on nuclear weapon phenomena and effects. It is intended to give initial bibliographic guidance to individuals new to the study of nuclear weapon phenomena and effects, to those experienced in a particular area but wishing to expand their knowledge into another area, and to those about to begin a survey of a particular phenomenon or effects subject.

This Guide is based on the reference collection of DASIAC, the DOD Nuclear Information and Analysis Center. DASIAC is the focal point for information and data on nuclear weapon explosions phenomenology and effects on military systems.* This Guide supersedes a 1972 version entitled A Guide to Nuclear Weapons Effects Literature (DASIAC SR 102 R).

The literature reviews are organized into the following four categories, each of which is given an alphabetic letter designator for cross-referencing:

Section 2: Comprehensive and Summary Literature (C)

Section 3: Nuclear Weapon Phenomena (P)

Section 4: Nuclear Weapon Effects (E)

Section 5: Special Reference Materials (R).

The phenomena and effects sections are further broken down into subsections (with one or two additional letter designators for cross-referencing), e.g., air shock in the phenomena section (designated as PA) and naval systems in the effects section (designated as EN). The complete listing of sections, subsections, and alphabetic designators is shown in the Table of Contents. Appendix A is a listing of acronyms and abbreviations used.

Within each section or subsection, the most significant, basic, and authoritative references are very briefly described. Bibliographic information for each source document is included with its discussion so a reader interested in a particular phenomenon or effects on a particular system need only refer to the few pages dealing specifically with his area of interest. For cross-referencing purposes, each source document is referred to by its letter designator and a numerical serial number. For example, the third source document regarding nuclear weapon effects on personnel is designated as "Reference EP-3."

* DASIAC has prepared, under separate cover, A Guide to Nuclear Warfare and Policy Literature (DASIAC SR 207).

Source documents are generally discussed within their most logical categories, but a simple categorization is not always possible. For example, effects on pyrotechnics are included in the subsection of effects on aerospace systems, which is the primary interest, although pyrotechnics also apply to other military systems. Effects on Army missiles are included in the subsection on effects on ground forces field equipment, rather than effects on aerospace systems. Therefore, a reader should review all subsections that may relate to his interest. This is facilitated by the brevity of the text.

The cited references are available at DASIAC for review by authorized visitors (for convenience, the DASIAC reference number is given with the bibliographic data); however, DASIAC does not loan or distribute reports. Whenever known, the ordering numbers (AD numbers) assigned by the Defense Technical Information Center (DTIC) are included so that qualified requesters can order reports of interest.

SECTION 2

COMPREHENSIVE AND SUMMARY LITERATURE (C)

There are two primary comprehensive overviews of nuclear weapons phenomena and effects, one of which is unclassified.

The Effects of Nuclear Weapons (Reference C-1) is without question THE basic and comprehensive unclassified overview. It is so well known throughout the NWE community that it is often referred to simply as "Glasstone," the single editor of the first two editions, or "ENW," from its title. All nuclear weapon phenomena and effects (primarily non-military) are lucidly discussed in both lay and technical terms, making this excellent reference the first choice for a reader in search of a broad and concise authoritative survey of the entire field.

Capabilities of Nuclear Weapons, DNA EM-1 (Reference C-2), is the best single comprehensive reference on all aspects of nuclear weapon phenomena and effects. This classified two-volume set both complements and supplements The Effects of Nuclear Weapons. Volume 1 focuses on nuclear weapon phenomenology and Volume 2 covers nuclear weapon effects that are primarily of military interest. This major DNA handbook, often referred to by its report number "EM-1," was last published in 1972 (with minor revisions through 1981), but it is presently being completely revised. When updated, EM-1 will again serve its important role as a basic source document for the preparation of nuclear operational and employment manuals by the military services.

Each of the military services has published reports that may be considered comprehensive overviews. Systems Applications of Nuclear Technology is a nine-volume set of reports (AFSCM 500-series) on survivability and vulnerability of air force systems. The first volume (Reference C-3) is a comprehensive summary of nuclear weapon phenomena and effects; the other volumes of this 1970 publication apply to particular phenomena or effects and those that still pertain are referenced elsewhere in this Guide. Sourcebook for Free-Field Nuclear-Environment Data is a six-volume set of army reports (BRL R 1494) that describe nuclear weapon environments pertinent to ABM materials development. The first volume of this set (Reference C-4) summarizes nuclear weapon phenomena, although it also is relatively dated (1972 publication). The other volumes of this set that pertain to effects on aerospace systems are referenced in that subsection of this Guide. The Blast, Thermal, and Nuclear Radiation Environments Produced by Nuclear Detonations Over Water (Reference C-5) is a recent summary of those phenomena of naval interest. The environments are calculated using state-of-the-art (in early 1980's) computer codes. Handbook of Underwater Nuclear Explosions, DNA 1240-series (see Reference PW-1), supposedly treats all phenomena and effects from underwater explosions, but only water shock phenomena and effects are covered in detail; also, the material is from the 1960's. Recently, the navy has produced a three-volume Naval Warfare Publication (NWP) on navy nuclear weapons, nuclear explosion environment, and vulnerability of naval forces to nuclear explosions (Reference C-6). Volume 2 covers

nuclear explosions phenomena at sea and Volume 3 covers the response of naval ships and submarines, equipment, personnel, and systems to nuclear explosions phenomena. NWP-28 serves more as a handbook for ready reference, whereas DNA 1240 is more of a sourcebook for further research and analysis.

"Review of Nuclear Weapons Effects" (Reference C-7) by Harold Brode discusses nuclear weapon phenomena, primarily from a physics point of view. Although this paper is fairly old (1968), it is a useful overview. Phenomena are reduced to relatively simple analytical approximations.

DNA has sponsored the development of software for scientific and military applications of nuclear weapon phenomena and effects information, designed for use with hand-held calculators and small computers. Taken as a whole, these CROM packages (as they are known) comprehensively cover the field of nuclear weapons phenomena and effects. Since this program is ongoing and the CROMs are under constant development and improvement, interested readers should check with DNA or DASIAC to identify the current version of any particular CROM.

- C-1. The Effects of Nuclear Weapons, Third Edition, S. Glasstone and P.J. Dolan, editors, U.S. Department of Defense and U.S. Department of Energy, 653 pp., 1977. (Available from U.S. Government Printing Office as report 1977 0-213-794). (U)
- C-2. Capabilities of Nuclear Weapons (U), DNA EM-1 (2 volumes), Defense Nuclear Agency, 1,200 pp., 1972, with changes through 1 August 1981. (SRD)
- C-3. Systems Applications of Nuclear Technology (U), Nuclear Weapons Effects on Air Force Systems (U), AFSCM 500-1 (DASIAC 10556), U.S. Air Force Systems Command, 200 pp., April 1970. (SRD)
- C-4. Sourcebook for Free-Field Nuclear-Environment Data (U), Introduction (U), Phenomenology (U), Volume 1, BRL R 1494 (DASIAC 13410), A.A. Temperley, et al., U.S. Army Ballistic Research Laboratories, 71 pp., April 1972. (SRD)
- C-5. The Blast, Thermal, and Nuclear Radiation Environments Produced by Nuclear Detonations Over Water (U), NWEF Report 1169(R) (DASIAC 32729, AD C027485), D. Deitz, et al., Naval Weapons Evaluation Facility, 160 pp., February 1982. (SRD)
- C-6. Naval Warfare Publication 28 (U), NWP-28-series (3 volumes), U.S. Navy Chief of Naval Operations:
 - Navy Nuclear Weapons (U), NWP-28-1, March 1983. (S)
 - Nuclear Explosion Environment (U), NWP-28-2, July 1983. (S)
 - Vulnerability of Naval Forces to Nuclear Explosions (U), NWP-28-3 (not yet distributed). (S)
- C-7. "Review of Nuclear Weapons Effects" (DASIAC 08805), H.L. Brode, Annual Review of Nuclear Science, Volume 18, pp. 153-202, Annual Reviews, Inc., Palo Alto, CA, 1968. (U)

SECTION 3

NUCLEAR WEAPON PHENOMENA (P)

The references described in Section 2 generally cover all nuclear weapon phenomena and are the first choice for an overview of all aspects of nuclear weapon phenomena. Some other references are comprehensive for certain situations. Handbook for Nuclear Weapons Effects Under Arctic Conditions (Reference P-1) covers all the nuclear weapon phenomena and effects on the environment from low altitude and underwater bursts in the arctic. The other references discussed in this section generally focus on the specific phenomena of:

- Air shock
- Ground shock, cratering, and ejecta
- Water shock and related phenomena
- Initial ionizing radiations
- Thermal and optical
- EMP environments and interactions
- Cloud and fallout.

As discussed in Section 2, software for hand-held calculators is available for calculations of these phenomena.

The phenomenology of nuclear-induced atmospheric disturbances is discussed in "C³ Systems and the Atmosphere" in Section 4.

- P-1. Handbook for Nuclear Weapons Effects Under Arctic Conditions (U), K-80-143(R) (DASIAC 34758, AD C022311), by J.R. Keith and W.E. Wallace of Kaman Sciences Corporation for DNA, 369 pp., 30 April 1980. (SRD)

AIR SHOCK (PA)

The definitive source on nuclear airblast phenomena is DASA 1200, Nuclear Weapons Blast Phenomena (Reference PA-1). This five-volume set discusses the theory of airblast formation and propagation and theoretical and empirical scaling of all aspects of airblast phenomena, and summarizes airblast measurements. Current versions of the volumes date from 1971 to 1973. Volume I covers the source and development of free-field nuclear airblast. Supplement 1 to Volume I addresses airblast from special nuclear weapons. Volume II deals with airblast propagation along, and interaction with, the earth's surface. Supplement 1 to Volume II covers airblast propagation in tunnels and chambers. Volume III presents airblast as a function of HOB and distance for detonations in air, underground, and underwater. Volume IV addresses high-explosive simulation of nuclear explosions. Volume V is a compendium of airblast data parameters from atmospheric nuclear weapon tests.

Chapter 2 of NWEF 1169 (see Reference C-5) is a recent computation of airblast parameters over water using the state-of-the-art (in early 1980's) LAMB code.

Regarding non-nuclear airblast, Explosion Effects and Properties, Part 1 - Explosion Effects in Air (Reference PA-2) provides much data on high-explosive airblast phenomena as a function of scaled distance, HOB, type of HE, and other factors. Equivalent weights for various types of HE are given for impulse and pressure as functions of pressure regimes.

Engineering Design Handbook, Explosions in Air (Reference PA-3) covers both theoretical and experimental aspects of airblast technology. It is not limited to nuclear airblast, but treats all facets of airblast of Army interest, e.g., conventional weapons, shaped charges, and muzzle blast. It covers general phenomenology, theory, blast scaling, computational methods, and airblast experimentation aspects, including instrumentation, data collection, and data reduction methods. Part 2 contains the information that is classified or of limited distribution.

A BRL sourcebook on free-field airblast phenomena (Reference PA-4) is quite dated (1972), but may still be a useful summary.

The DNA Nuclear Blast Standard (1-KT) (Reference PA-5) is the current accepted standard for the description of the blast environment from a 1-kiloton, free-air detonation under standard atmospheric conditions.

Nuclear Airblast Summary for High Overpressures (Reference PA-6) contains a compilation of digitized plots of all available nuclear airblast overpressure waveforms with peak pressures above 100 psi, compared with equivalent waveforms from the analytical expressions (Brode Equations, from Reference C-7 and subsequent work) that have been adopted by the nuclear simulator development community as the standards for nuclear waveforms.

Several relatively recent reports provide improved analytical and simulated expressions for airblast parameters and waveforms. DNA 5741T (Reference PA-7) gives such expressions for peak overpressures and dynamic pressures, especially as functions of HOB.

Analysis of Uncertainty in the Prediction of Free-Field Environments from Explosions (Reference PA-8) is an 11-part set of recent reports that compiles and updates modern methods for predicting airblast and ground shock environments and for defining and quantifying uncertainties in the data. Parts 1 through 3 give the text discussion and Parts 4 through 11 show the data fits for nuclear and high-explosive events.

Reference PA-9 is a chapter from a West German manual on vulnerability of army systems that gives analytical functions of air shock properties for use with pocket calculators.

PA-1. Nuclear Weapons Blast Phenomena (U), DASA 1200-series (5 volumes), Defense Atomic Support Agency:

Volume I, Source and Development of Blast Waves in Air (U), DASA 1200-I (AD 516107), 837 pp., March 1971. (SRD) Supplement 1 - Air Blast Environments from Special Nuclear Weapons (U) (AD 523823L), 238 pp., 18 July 1972. (SRD-CNWDI)

Volume II, Blast Wave Interaction (U), DASA 1200-II (AD 513590), 608 pp., December 1970 (revised 22 October 1971). (CFRD) Supplement 1 - Air Blast in Tunnels and Chambers (U) (AD 906986L), October 1972. (U)

Volume III, Air and Subsurface Explosions (U), DASA 1200-III (AD 511266L), 268 pp., March 1970 (revised 15 June 1972). (SFRD)

Volume IV, Simulation of Nuclear Airblast Phenomena with High Explosives (U), DASA 1200-IV (AD 527669), 300 pp., 31 July 1973. (SFRD)

Volume V, Data Compendium (U), DASA 1200-V (AD 503077L), 410 pp., June 1968 (revised 15 October 1971). (CFRD)

PA-2. Explosion Effects and Properties, Part 1 - Explosion Effects in Air, NSWC/WOL/TR 75-116 (DASIAC 23077, AD A018544), M.M. Swisdak, Jr., Naval Surface Weapons Center, White Oak, Silver Spring, MD, 139 pp., 6 October 1975. (U)

PA-3. Engineering Design Handbook, Explosions in Air (U), U.S. Army Material Command:

Part One (U), AMCP 706-181 (DASIAC 25518, AD 060858), 400 pp., 15 July 1974. (U)

Part Two (U), AMCP 706-182 (DASIAC 25405, AD 060857), 200 pp., August 1975. (SRD)

PA-4. Sourcebook for Free-Field Nuclear-Environment Data: The Free-Field Blast Environment (U), Volume 5, BRL R 1494 (DASIAC 13725, AD 520977L), N.H. Ethridge, et al., Ballistic Research Laboratories, 244 pp., April 1972. (SRD)

- PA-5. The DNA Nuclear Blast Standard (1-KT), DNA 5648T (AD B064540L), by C.E. Needham and J.E. Crepeau of Systems, Science and Software, Inc. for DNA, 168 pp., 30 January 1981. (U)
- PA-6. Nuclear Airblast Summary for High Overpressures (U), AFWL-TR-81-47 (DASIAC 33270, AD C029890L), H.W. Wampler and R.C. Bair of New Mexico Engineering Research Institute, University of New Mexico, for the Air Force Weapons Laboratory, 78 pp., September 1982. (SRD)
- PA-7. Fire, Airblast, and Underground Effects from Nuclear Explosions - Some Current Progress, DNA 5741T (AD B069574L), by H.L. Brode, et al., of Pacific-Sierra Research Corp. for DNA, 244 pp., 1 January 1981. (U)
- PA-8. Analysis of Uncertainty in the Prediction of Free-Field Environments from Explosions, AFWL-TR-81-82, Parts 1 through 11 (DASIAC 31794 through 31804), by C.J. Higgins, et al., of Applied Research Associates, Inc. for the Air Force Weapons Laboratory, 480 pp. text and 2101 pp. appendices, January 1982. (U)
- PA-9. Manual for Assessing the Vulnerability of Defense Equipment of the Army as the Result of Atomic Air Shock Waves, Part I, The Properties of the Air Shock Wave, FTD-ID(RS)T-0303-83 (DASIAC 34181, AD B074173), K.A. Kohler and H. Reichenbach of West Germany (translated 4 May 1983 from German for the Foreign Technology Division, Wright-Patterson AFB, OH), 92 pp., 1977. (U)

GROUND SHOCK, CRATERING, AND EJECTA (PG)

Nuclear Geoplosics: A Sourcebook of Underground Phenomena and Effects of Nuclear Explosions, DASA 1285-series (Reference PG-1), is the basic sourcebook on explosion-induced ground motions and related phenomena. As the titles of the five volumes indicate, the set includes discussion of theory of ground motion, earth material properties, test sites and instrumentation, empirical data on ground motion and cratering, and effects on underground structures and equipment. However, except for Volume IV, the current volumes of this sourcebook are quite old. Volume IV of the original set has been greatly expanded to include data from high-explosive simulations and reissued as DNA 6501H-4 (Reference PG-2), a two-volume set on empirical data and analysis of ground motion, cratering, and ejecta phenomena.

Analysis of Uncertainty in the Prediction of Free-Field Environments from Explosions (Reference PG-3) is a recent 11-part set of reports that compiles and updates modern methods for predicting airblast and ground shock environments and for defining and quantifying uncertainties in the data. Parts 1 through 3 give the text discussion and Parts 4 through 11 show the data fits for nuclear and high-explosive events. Ground Motion Environments for Generic Site Conditions (Reference PG-4) is a 1975 state-of-the-art review for providing methods to predict and scale airblast and ground shock environments generated by nuclear explosions in various generic geologies. Multiple Burst Ground Shock Environments (Reference PG-5) is a recent evaluation of the Waveforms Synthesis Model for predicting both single- and multiburst ground shock environments. Numerical Simulations of Cratering and Ground Shock from High-Explosive and Nuclear Tests (Reference PG-6) evaluates the current (1980) capabilities of such simulations. "A Back-of-the-Envelope Approach to Predicting Ground Motion Phenomena" (Reference PG-7) presents a simple analytic model for ground motion that shows good agreement with empirical data over a wide range of times, pressures, and distances.

"The Theory of Cratering Phenomena, an Overview" (Reference PG-8) concisely describes the physical processes of cratering and examines theoretical capabilities for crater prediction. (The book of this symposium proceedings has other articles of interest on cratering.) Nuclear Cratering (Reference PG-9) is intended as a relatively simple presentation of the important physical processes involved in cratering along with their spatial and temporal scales. Cratering by Explosions: A Compendium and an Analysis (Reference PG-10) tabulates basic data on explosives parameters, earth media, and crater and ejecta dimensions for nuclear and high-explosive simulations. The data are organized into various meaningful categories (e.g., by earth type) and analyzed to develop analytical relationships. A Compendium of Data from Laboratory-Scale High-Explosive Cratering and Ejecta Studies (Reference PG-11) tabulates crater and ejecta data from over 650 gram-sized high-explosive charges detonated at various near-surface HOB/DOBs. Estimates of Crater Dimensions for Near-Surface Explosions of Nuclear and High-Explosive Sources (Reference PG-12) shows procedures for predicting crater dimensions from nuclear explosions in various geologic media and for scaling to other conditions. The procedures are based on an analysis of high-explosive and nuclear crater data and quantification of the cratering efficiency of various geologies.

- PG-1. Nuclear Geoplosics: A Sourcebook of Underground Phenomena and Effects of Nuclear Explosions, DASA 1285-series (5 volumes), Defense Atomic Support Agency/Defense Nuclear Agency:

Part One - Theory of Directly-Induced Ground Motion, DASA-1285(I) (AD 443592), by J. Naar of Stanford Research Institute for DASA, 51 pp., May 1964. (U)

Part Two: Mechanical Properties of Earth Materials, DNA 1285H2, by J. Isenberg of Agabian Associates for DNA, 137 pp., November 1972. (U)

Part Three - Test Sites and Instrumentation, DASA-1285(III) (AD 281777), by P.L. Flanders of Stanford Research Institute for DASA, 84 pp., May 1964. (U)

Part Four - Empirical Analysis of Ground Motion and Cratering, DASA-1285(IV) (AD 443593), by F.M. Sauer, et al., for DASA, 91 pp., May 1964. (U) (However, see Reference PG-2.)

Part Five - Effects on Underground Structures and Equipment, DASA-1285(V) (AD 443589), by J.L. Merritt and N.M. Newmark of N.M. Newmark Associates for DASA, 186 pp., May 1964. (U)

- PG-2. Nuclear Geoplosics Sourcebook, Volume IV, DNA 6501H-4-series, edited by J.E. Schoutens of General Electric Tempo, DASIAC, for DNA:

Part I - Empirical Analysis of Ground Motion from Above and Underground Explosions, DNA 6501H-4-1 (AD A095096), 370 pp., 1 March 1979. (U)

Part II - Empirical Analysis of Nuclear and High-Explosive Cratering and Ejecta, DNA 6501H-4-2 (AD A095097), 464 pp., 1 March 1979. (U)

- PG-3. Analysis of Uncertainty in the Prediction of Free-Field Environments from Explosions, AFWL-TR-81-82, Parts 1 through 11 (DASIAC 31794 through 31804), by C.J. Higgins, et al., of Applied Research Associates, Inc. for the Air Force Weapons Laboratory, 480 pp. text and 2101 pp. appendices, January 1982. (U)

- PG-4. Ground Motion Environments for Generic Site Conditions, DNA 3872F (AD B015542L), by N. Lipner, et al., of TRW Systems Group for DNA, 204 pp., 31 December 1975. (U)

- PG-5. Multiple Burst Ground Shock Environments, AFWL-TR-81-144 (DASIAC 31859, AD B064561L), by J.L. Bratton, et al., of Science Applications, Inc. for the Air Force Weapons Laboratory, 232 pp., March 1982. (U)

- PG-6. Numerical Simulations of Cratering and Ground Shock from High Explosive and Nuclear Tests, AFWL-TR-79-2 (DASIAC 29677), P.T. Dzwilewski and G.W. Ullrich, Air Force Weapons Laboratory, 176 pp., May 1980. (U)

- PG-7. "A Back-of-the-Envelope Approach to Predicting Ground Motion Phenomena" (DASIAC 23431), S.R. Kurtz, Journal of Geophysical Research, Volume 80, Number 32, pp. 4449-4460, November 10, 1975. (U)
- PG-8. "The Theory of Cratering Phenomena, an Overview," C.P. Knowles and H.L. Brode, Impact and Explosion Cratering: Planetary and Terrestrial Implications, Proceedings of the Symposium on Planetary Cratering Mechanics, Flagstaff, AZ, September 13-17, 1976, Pergamon Press, pp. 869-895. (U)
- PG-9. Nuclear Cratering, JSR-79-09 (DASIAC 32054, AD 103435), H.M. Foley, et al., SRI International, Arlington, VA, 100 pp., June 1980. (U)
- PG-10. Cratering by Explosions: A Compendium and an Analysis, Technical Report N-74-1 (DASIAC 17347, AD B024657L), A.D. Rooke, et al., Waterways Experiment Station, 339 pp., January 1974. (U)
- PG-11. A Compendium of Data from Laboratory-Scale High-Explosive Cratering and Ejecta Studies, AFWL-TR-80-86 (DASIAC 30877), by A.J. Piekutowski of University of Dayton Research Institute for the Air Force Weapons Laboratory, 678 pp., May 1981. (U)
- PG-12. Estimates of Crater Dimensions for Near-Surface Explosions of Nuclear and High-Explosive Sources, RDA-TR-2604-001 (DASIAC 24606), H.F. Cooper, Jr., R&D Associates, Marina Del Rey, CA, 53 pp., October 1976. (U)

WATER SHOCK AND RELATED PHENOMENA (PW)

Volume 1 of Handbook of Underwater Nuclear Explosions, DNA 1240H-1 (Reference PW-1), is the definitive sourcebook on water shock and related phenomena. It covers water shock waves and interactions, explosion bubbles, surface phenomena, underwater craters and debris, and ionizing radiation. (Volumes 2 and 3 cover effects of naval interest from underwater explosions.) Nuclear Explosion Environment (see Reference C-6) is a recent NWP on phenomena of nuclear explosions at sea. Nuclear Explosions at Sea, a State-of-the-Art Study of Selected Nuclear Weapons Effects (Reference PW-2) is a summary survey of nuclear weapons effects phenomenology for abovewater and underwater nuclear bursts and blast and shock effects on ships and ships systems. Aids for Rapid Estimation of Weapons Effects (Reference PW-3) gives equations, graphs, nomographs, and procedures for rapid estimation of blast and shock phenomena and response of naval structures to underwater, air, and water surface bursts of nuclear and conventional weapons. Explosion Effects and Properties: Part II - Explosion Effects in Water (Reference PW-4) compiles information on underwater shock phenomenology, but only for conventional explosives.

Handbook of Explosion-Generated Water Waves, DASA 2450 (Reference PW-5), is the primary reference on water surface waves phenomena. Wave Making by an Underwater Explosion (Reference PW-6) summarizes the history of water wave making by explosions, discusses the various theories and makes comparisons to empirical data, and examines scaling laws. Surface Wave Prediction for Explosions in Shallow Water, DNA 5210F (Reference PW-7), reviews the data base for underwater and surface explosions, develops simple expressions for predicting maximum wave height, and describes a numerical model that compares favorably with the data.

See the "Cloud and Fallout" subsection of this Guide for references to clouds from underwater explosions.

- PW-1. Handbook of Underwater Nuclear Explosions (U), Volume 1, DNA 1240H-1 (AD 523834), Defense Nuclear Agency, March 1971. Part 1 (AD 520206), 826 pp. (CFRD) Part 2, 636 pp. (SRD)
- PW-2. Nuclear Explosions at Sea, A State-of-the-Art Study of Selected Nuclear Weapons Effects (U), NOLTR 72-20 (DASIAC 13765), D. Levine, editor, Naval Ordnance Laboratory, White Oak, Silver Spring, MD, 150 pp., 7 January 1972. (SRD)
- PW-3. Aids for Rapid Estimation of Weapons Effects (U), Second Revision, Report C-1590 (DASIAC 10979, AD 505496), P.A. Manny, Naval Ship Research and Development Center, Washington, D.C., 109 pp., January 1969. (C)
- PW-4. Explosion Effects and Properties: Part II - Explosion Effects in Water, NSWC/WOL TR 76-116 (DASIAC 26328, AD A056694), M.M. Swisdak, Jr., editor, Naval Surface Weapons Center, White Oak, Silver Spring, MD, 109 pp., 22 February 1978. (U)
- PW-5. Handbook of Explosion-Generated Water Waves (U), DASA 2450, by B.L. Mehaute, et al., of Tetra Tech., Inc. for Office of Naval Research:

Volume 1 (AD 845485L), 166 pp., October 1968. (U)

Volume 2 (AD 506914L), 168 pp., December 1969. (S)

- PW-6. Wave Making by an Underwater Explosion, NSWC/WOL MP 76-15 (DASIAC 25627, AD A038276), G.K. Hartmann, Naval Surface Weapons Center, White Oak, Silver Spring, MD, 159 pp., September 1976. (U)
- PW-7. Surface Wave Prediction for Explosions in Shallow Water (U), DNA 5210F (AD C022973), by R.T. Allen of Pacifica Technology for DNA, 76 pp., 21 December 1979. (SFRD)

INITIAL IONIZING RADIATIONS (PI)

DNA Nuclear Weapons Output Handbook, DNA 3728H (Reference PI-1), is the basic handbook on ionizing radiation output from nuclear devices and has relegated the previous major source documents on weapon output (DASA 2383, DASA 2397, and DNA 2866) to mainly historical references. This relatively recently revised handbook includes tabular and graphical data on stockpile and experimental devices and those used in underground tests.

The neutron and gamma data collected from atmospheric weapon tests have been compiled into five reports (References PI-2 through PI-6). These reports cite the sources of the original data. No scaling or adjusting, other than for the most obvious corrections, has been done to these data. The neutron data collected by DOD are given in References PI-2 and PI-3; all the data are for line-of-sight measurements. The neutron data collected by the Los Alamos Scientific Laboratory, given in WT-9004 (Reference PI-4), include some data from special experiments involving shielded measurements. The initial gamma experimental measurements for atmospheric tests from 1948 through 1962 have been compiled into References PI-5 and PI-6.

Weapons Radiation Shielding Handbook (Reference PI-7) provides a textbook treatment of neutron/gamma radiation transport and shielding, although the volumes are quite dated and the set is incomplete. (The handbook consists of six volumes that were originally intended to be individual chapters of a comprehensive handbook.)

Neutron and gamma radiation levels and tissue doses, after transport through air and shielding materials, are typically computed by complex computer codes as a function of burst parameters, range, etc. There are a number of major compilations of the results of such code computations, but many of them are of 1960's and early 1970's vintage and are not referenced in this Guide. Chapter 4 of NWEF 1169 (see Reference C-5) shows free-field tissue dose for nuclear detonations over water, computed by a version of the TWOTRAN code. The computations are free-field in that they do not assume shielding by a ship, but they do include the factors that pertain to air-over-seawater radiation transport.

DNA 4267F, Radiation Environments from Tactical Nuclear Weapons (Reference PI-8), is a comprehensive data base for predicting the free-field and armor-shielded tissue dose in an air-over-ground geometry for arbitrary weapon spectra and heights of burst. Both prompt and delayed radiation are included.

Current information on radiation transport and shielding can be obtained from the Radiation Shielding Information Center (RSIC) at Oak Ridge, TN.

- PI-1. DNA Nuclear Weapons Output Handbook (U), DNA 3728H Rev. 1 (DTL-062029), by C.E. Wilson, et al., of Systems, Science, and Software for DNA, 652 pp., 1 August 1979. (SRD-CNWDI)
- PI-2. External Neutron Measurements 1952 Through 1958 (U), CWLR 2377 (DASIAC 02294), J.H. McNeilly, et al., U.S. Army Chemical Warfare Laboratories, 140 pp., March 1960. (SRD)

- PI-3. Neutron Measurements for Weapons Tests from 1959 to 1962 (U), NDL-TR-95 (DASIAC 06706, AD 385927), R.J. Smith, U.S. Army Nuclear Defense Laboratory, 58 pp., November 1967. (SRD)
- PI-4. General Report on Weapons Tests, External Neutron Measurements 1946 Through 1956 (U), WT-9004, W.A. Biggers and F. Waddell, Los Alamos Scientific Laboratory, 202 pp., 8 October 1957. (SRD)
- PI-5. Initial Gamma Data from Nuclear Weapon Tests 1948 through 1962 (U), NDL-TR-53 (DASIAC 04462, AD 365419L), R.J. Smith, et al., U.S. Army Nuclear Defense Laboratory, 240 pp., July 1965. (SRD)
- PI-6. Gamma Dose Rate Compilation (U), NDL-TR-54 (DASIAC 04643, AD 375372L), W.E. Loewe, et al., U.S. Army Nuclear Defense Laboratory, 251 pp., June 1966. (SRD)
- PI-7. Neutron and Gamma-Ray Albedos (Reprint of Chapter 4 of Weapons Radiation Shielding Handbook), ORNL-RSIC-21, DASA-1892-2 (AD 816092L), by W.E. Selph of Radiation Shielding Information Center, 54 pp., February 1968. (U)

Weapons Radiation Shielding Handbook, DASA 1892-series (6 volumes), edited by L.S. Abbott, et al., of Oak Ridge National Laboratory for DASA/DNA:

Chapter 5: Methods for Calculating Effects of Ducts, Access Ways, and Holes in Shields, DASA-1892-1 (AD 804869L), by W.E. Selph, et al., 49 pp., December 1966. (U)

Chapter 3: Methods for Calculating Neutron and Gamma-Ray Attenuation, DNA-1892-3 Rev. 1, by P.N. Stevens, et al., 184 pp., March 1972. (U)

Chapter 6: Methods for Predicting Radiation Fields Produced by Nuclear Weapons, DASA-1892-4, by W.E. Selph and M.B. Wells, 330 pp., December 1969. (SRD-CNWDI)

Chapter 2: Basic Concepts of Radiation Shielding Analysis, DASA-1892-5 (AD 707082), by P.N. Stevens and H.C. Claiborne, 85 pp., June 1970. (U)

Chapter 7: Engineering Method for Designing Initial Radiation Shields for Blast-Hardened Underground Structures, DASA-1892-6, by L.G. Mooney, et al., 127 pp., October 1970. (SRD)

- PI-8. Radiation Environments from Tactical Nuclear Weapons, DNA 4267F (AD A047389), by M.R. Gritzner, et al., of Science Applications, Inc. for Defense Nuclear Agency, 260 pp., July 1976. (U)

THERMAL AND OPTICAL (PT)

Nuclear Weapons Thermal Radiation Phenomena, DNA 2500H-series (Reference PT-1), is the basic sourcebook on the subject. Although nominally divided into three volumes, this mammoth sourcebook actually comprises nine separately-bound parts. Volume 1 covers analysis and data correlation and is divided into separate parts on (1) thermal pulse and fireball phenomenology, (2) atmospheric transmission, and (3) nuclear weapons test data and semi-empirical scaling laws. (The Preface indicates that portions of this 1981 volume were previously published by Wells and Keith and therefore are not updated evaluations.) Volume 2, published in 1974 in five separate parts, presents a complete tabulation of all thermal radiation measurements from U.S. atmospheric nuclear tests. Volume 3 is a 1974 bibliography on the subject.

Because of its relative newness and the comprehensive treatment of the data, DNA 2500H appears to suffice as the single basic source document on nuclear thermal environments and to have superseded a number of other basic and comprehensive references. These supplanted references include: Characteristics of the Thermal Radiation from Nuclear Detonations, AFSWP 902, a three-volume 1959 compendium of thermal test data; Spectral and Total Thermal Radiant Power and Energy Histories and Distribution: Operations Dominic, Christmas Island and Fishbowl Series, DASA 1663, a five-volume set of data on air detonations; and Thermal Radiation Phenomena, DASA 1917 (with the first three volumes mismarked as DASA 1971), a six-volume set giving much detail on basic air properties as they pertain to radiation hydrodynamics. (Theoretical Models for Nuclear Fireballs, DASA 1589, a 41-volume set of radiation hydrodynamic calculations by the Fireball code for 39 theoretical low-altitude nuclear bursts, may still be of use.)

Source Book of Optical and Thermal Data from Major Trials (Reference PT-2) is a four-volume thermal environment sourcebook for the major British atmospheric tests. The various source documents from which the information is extracted are referenced throughout the reports.

Nuclear IR Data Review (Reference PT-3) is a major summary and data review of the measured infrared and optical data (wavelengths greater than 0.65 μm) from U.S. atmospheric nuclear tests.

Chapter 3 of NWEF 1169 (see Reference C-5) shows thermal radiation fluence levels over water, as computed by the TRAP code.

PT-1. Nuclear Weapons Thermal Radiation Phenomena (U), DNA 2500H-series (9 separately-bound parts in 3 volumes), by Kaman Sciences Corporation for DNA:

Volume 1, Analysis and Data Correlation (U), 1 April 1981

Part 1 - Thermal Pulse and Fireball Phenomenology (U), DNA 2500H-1A (AD C031807), by D.C. Sachs and J.R. Keith, 262 pp. (SRD)

Part 2 - Atmospheric Transmission (U), DNA 2500H-1B (AD B074914L), by J.R. Keith, 536 pp. (U)

Part 3 - Nuclear Weapons Test Data and Semi-Empirical Scaling Laws (U), DNA 2500H-1C (AD C033232), by J.R. Keith and P.B. Wells, 144 pp. (SRD)

Volume 2, Weapons Test Data Tabulation (U) (5 separately-bound reports), by P.B. Wells, et al., of Kaman Sciences for DNA, 26 July 1974:

Part 1, Operations Greenhouse, Buster-Jangle, Tumbler-Snapper and Ivy (U), DNA 2500H-2A (AD 531090L), 480 pp. (SRD)

Part 2, Operations Upshot-Knothole, Castle and Teapot (U), DNA 2500H-2B (AD 531091L), 484 pp. (SRD)

Part 3, Operations Redwing and Plumbbob (U), DNA 2500H-2C (AD 531092L), 494 pp. (SRD)

Part 4, Operations Hardtack I, Hardtack II and Dominic (U), DNA 2500H-2D (AD 531302L), 588 pp. (SRD)

Part 5, Operations Dominic (Continued) and Sunbeam (U), DNA 2500H-2E (AD 531303L), 530 pp. (SRD)

Volume 3, Bibliography (U), DNA 2500H-3 (AD 530246L), by P.B. Wells, et al., 554 pp., 15 February 1974. (U)

PT-2. Source Book of Optical and Thermal Data from Major Trials (U) (4-volume AWRE report), compiled by D.E. Lloyd and B.E. Belcher, AWRE, Aldermaston, Berks., March 1977:

Part 1 - General Information (U), AWRE T 1/77 (DASIAC 24963), 94 pp. (SRD, Atomic)

Part 2 - Hurricane, Totem and Mosaic (U), AWRE T 2/77 (DASIAC 24964), 75 pp. (SRD, Atomic Principal)

Part 3 - Buffalo - Antler (U), AWRE T 3/77 (DASIAC 24965), 112 pp. (SRD, Atomic Principal)

Part 4 - Grapple Series Thermal and Photographic Measurements (U), AWRE T 4/77 (DASIAC 24966), 58 pp. (SRD, Atomic Principal)

PT-3. Nuclear IR Data Review (U), AFGL-TR-80-0184(I), (II), and (III) (3 volumes) (DASIAC 33599, 600, and 601, AD C031356, 57, and 58), J.W. Reed, et al., of Visidyne, Inc. for the Air Force Geophysics Laboratory, Hanscom AFB, MA 01731, 1,898 pp., 15 May 1980. (SRD)

EMP ENVIRONMENTS AND INTERACTIONS (PE)

Since EMP has been of great interest within the NWE community in recent years, there are a number of fairly recent major references, many of which are unclassified. References PE-1 and PE-2, however, can be considered as the two basic references that survey the entire field of EMP.

DNA EMP Awareness Course Notes (Reference PE-1) is a basic unclassified introduction to nuclear weapon EMP and systems design for EMP protection.

DNA EMP (Electromagnetic Pulse) Handbook, DNA 2114H (Reference PE-2), is a classified six-volume comprehensive review of all aspects of EMP. Volume 1 gives design principles for the practical engineer and EMP hardening manager. Volume 2 is for the theoretical or experimental analyst who must deal with EMP coupling. Volume 3 contains data on component damage and upset, and on test hardware and facilities. Volume 4 describes the EMP environment, effects on in-flight systems, and SGEMP. Volume 5 is a guide to further study, including a basic reading list with abstracts. Volume 6 compares and gives details on environment, coupling, and circuit analysis computer codes.

The book, EMP Radiation & Protective Techniques (Reference PE-3), and Bell Laboratories publication, EMP Engineering and Design Principles (Reference PE-4), are also recommended as basic overviews of EMP.

Electromagnetic Pulse Environment Handbook (Reference PE-5) gives additional classified details about EMP environments. EMP Interaction: Principles, Techniques and Reference Data (Reference PE-6) is an exhaustive unclassified treatment of that subject, taken from the EMP Interaction Notes. (The Air Force Weapons Laboratory has published a series of over 400 EMP interaction notes over a period of years, primarily for use of the EMP specialist. Individual titles are given in Volume 5 of the DNA EMP Handbook, Reference PE-2.)

System Generated Electromagnetic Pulse (SGEMP) User's Manual (Reference PE-7) covers SGEMP as it relates to testing and hardening satellites. Volume I, for program planners and managers, provides a methodology and sufficient information for planning a satellite SGEMP survivability program. Volume II, for design engineers, presents the guidelines, evaluation techniques, and data needed for the tradeoffs required in the development of hardened design. Volume III, for nuclear hardness and survivability engineers, treats the technical aspects of SGEMP phenomenology and coupling. Volume III also contains an annotated bibliography of the more important papers and reports on SGEMP.

Theory of EMP Coupling in the Source Region (Reference PE-8) presents methods, primarily analytical, for calculating the coupling of EMP to systems in the source region, an area of current high interest within the EMP community. The physics of magnetohydrodynamic EMP (MHDEMP) and the environment created by this phenomenon are discussed in A Model for MHDEMP From a High Altitude Nuclear Burst (Reference PE-9) and Magnetohydrodynamic EMP Environments (Reference PE-10).

Additional information on EMP environments and interaction is given in the references cited in Section 4 of this Guide. Also, the Telecommunications

Electromagnetic Pulse (EMP) Index (Reference PE-11) gives a basic reading list with abstracts and indexes 1,400 pertinent EMP references.

PE-1. DNA EMP Awareness Course Notes, Third Edition, DNA 2772T (AD A058367), by I.N. Mindel of IIT Research Institute for DNA, 278 pp., October 1977, and Supplement to Third Edition (AD A083485), 36 pp., 31 July 1978. (U)

PE-2. DNA EMP (Electromagnetic Pulse) Handbook (U), DNA 2114H-series (6 volumes), by J.F. Sweton of Harry Diamond Laboratories for DNA, 5 July 1979:

Volume 1 - Design Principals (U), DNA 2114H-1 (AD C019488), 460 pp. (C)

Volume 2 - Coupling Analysis (U), DNA 2114H-2 (AD C019587), 636 pp. (C)

Volume 3 - Component Response and Test Methods (U), DNA 2114H-3 (AD C019489), 516 pp. (C)

Volume 4 - Environment and Applications (U), DNA 2114H-4 (AD C019490), 366 pp. (C)

Volume 5 - Resources (U), DNA 2114H-5 (AD C019491), 500 pp. (C)

Volume 6 - Computer Codes (U), DNA 2114H-6 (AD C019492), 276 pp. (C)

PE-3. EMP Radiation & Protective Techniques (DASIAC 25212), L.W. Ricketts, J.E. Bridges, and J. Miletta, published by John Wiley and Sons, 380 pp., 1976. (U)

PE-4. EMP Engineering and Design Principles (DASIAC 21923), Bell Telephone Laboratories, Inc., Loop Transmission Division, Whippany, NY 07981, 151 pp., 1975. (U)

PE-5. Electromagnetic Pulse Environment Handbook (U), AFWL EMP Phenomenology 1-1 (DASIAC 13142, AD 519380L), G.K. Schlegel, et al., Air Force Weapons Laboratory, 569 pp., January 1972. (SRD-CNWDI)

PE-6. EMP Interaction: Principles, Techniques and Reference Data (A Complete Concatenation of Technology from the EMP Interaction Notes), EMP Interaction 2-1, AFWL-TR-80-402 (DASIAC 30184, AD A100508), edited by K.S.H. Lee of Dikewood Industries, Inc. for the Air Force Weapons Laboratory, 762 pp., December 1980. (U)

PE-7. System Generated Electromagnetic Pulse (SGEMP) User's Manual, DNA 5949-series (3 volumes in final preparation), by W. McNamara, et al., of Kaman Tempo for DNA, 31 December 1981:

Volume I: Program Planning and Implementation, DNA 5949-1. (U)

Volume II: Design and Evaluation, DNA 5949-2.

Volume III: SGEMP Coupling Technology and Specifications Development, DNA 5949-3.

- PE-8. Theory of EMP Coupling in the Source Region, DNA 5687F (AD A108751), by C.L. Longmire and J.L. Gilbert of Mission Research Corporation for DNA, 216 pp., 28 February 1980. (U)
- PE-9. A Model for MHD EMP From a High Altitude Nuclear Burst (U), DNA 6119T (AD C032890), by N.J. Carron of Mission Research Corporation for DNA, 68 pp., 1 January 1982. (C)
- PE-10. Magnetohydrodynamic EMP Environments (U), DNA-TR-82-25, by N.J. Carron and C.L. Longmire of Mission Research Corporation for DNA, 60 pp., 10 September 1982. (SFRD)
- PE-11. Telecommunications Electromagnetic Pulse (EMP) Index (U), NCS TIB 84-1 (DASIAC 34543, AD C034026L), by D.A. Reitz of Kaman Tempo, DASIAC, for National Communications System Office of Technology and Standards (NCS-TS), Washington, D.C. 20305, 238 pp., January 1984. (C)

CLOUD AND FALLOUT (PC)

Nuclear test fallout data are summarized and assembled in DASA 1251, Local Fallout from Nuclear Test Detonations (Reference PC-1). Excerpts from weapon test reports are used in this multivolume set (nine separately-bound parts) to (1) compile fallout patterns and related test data from all atmospheric tests, (2) provide a compendium of data on physical, chemical, radiochemical, and radiation characteristics of fallout, and (3) discuss factors influencing transport and deposition. Reference PC-2 is an unclassified compilation of fallout data extracted from DASA 1251.

Volume 3 of DASA 1251 gives considerable cloud dimensional data, but some more recent work has been carried out to derive additional cloud dimensions versus time, mostly from analysis of test photography. Nuclear Cloud Dimensional Data (Reference PC-3) gives dimensions versus time for clouds from 15 water-surface or underwater nuclear tests and of the main clouds (primarily) for 60 nuclear events on land. Nuclear Cloud Stem Data Analysis (Reference PC-4) gives dimensions of cloud stems for 31 nuclear events. Nuclear Precursor Phenomenology and Sweep-Up Dust Cloud Model Development (Reference PC-5) gives dimensions of dust pedestals for 36 events. Nuclear Cloud Data and Predictive Uncertainties (Reference PC-6) presents statistical fits to the empirical data on cloud dimensions.

The above-surface phenomena of crown, column, plumes, and base surge are addressed in Chapter 7 of Volume 1 of the Handbook of Underwater Nuclear Explosions (see Reference PW-1). Reference PC-7 is a more recent (but still old) study of dimensions and densities of underwater explosion clouds.

Dust and water/ice in nuclear clouds have been of much interest in recent years. The executive summary of the 1978 DNA Nuclear Dust Environment Symposium (Reference PC-8) summarizes in only eight pages the status and research at that time regarding cloud models, environment and effects simulations, and dust effects on strategic and tactical systems. Nuclear Explosion Dust Cloud Phenomena--A Guide to the Literature (Reference PC-9) discusses and gives references for dust phenomena from nuclear and high-explosive events and for dust environment computer codes. Two recent summaries on dust clouds are Introduction to Nuclear Dust/Debris Cloud Formation (Reference PC-10) and Dust from Low Altitude Bursts (Reference PC-11); both discuss debris sources, phenomenology of cloud formation, and scaling. In addition to dimensional data, Reference PC-6 addresses mass loading of clouds and predictive computer codes for dust clouds.

For fallout itself, The History of Fallout Prediction (Reference PC-12) is a useful overview of events up to 1979. FM 3-22, Fallout Prediction (Reference PC-13), is the army Field Manual on the subject for practical field conditions. DELFIC is a large and complex computer model for predicting deposition of local fallout from detonations of all practical yields and HOBs. The fundamentals of DELFIC and a user's manual are given in DELFIC: Department of Defense Fallout Prediction System (Reference PC-14), a major consolidation of many previous volumes of program description and incorporating considerable programming improvements. DELFIC is, however, designed as a research tool and the standard against which other simpler models are judged. Analysis and Comparison of Fallout Prediction Models (Reference PC-15) is such a comparison.

Fallout: Its Characteristics and Management (Reference PC-16) is a recently-published comprehensive single-source summary of fallout phenomena and effects, primarily from the standpoint of U.S. civil defense.

Although it is fairly old, the Proceedings for a 1961 AEC conference, Radioactive Fallout from Nuclear Weapons Tests (Reference PC-17), comprehensively addresses global fallout and distribution and cycling of fallout nuclides in the environment and food chain. The 1980 Symposium on Intermediate Range Atmospheric Transport Processes and Technology Assessment was oriented toward air pollution rather than nuclear explosion clouds, but the Proceedings (Reference PC-18) may be useful because the symposium focused on the critical downrange distances of 10 to 100 km.

PC-1. Local Fallout from Nuclear Test Detonations (U), DASA 1251-series (5 volumes with 9 separately-bound parts), by U.S. Army Nuclear Defense Laboratory for the Defense Atomic Support Agency:

Volume I, Indexed Bibliography of United States and British Documents on Characteristics of Local Fallout (U), DASA 1251-1 (AD 329971), 237 pp., 27 June 1961. (C)

Volume II, Compilation of Fallout Patterns and Related Test Data (U):

Part 1 - Trinity Through Redwing (U), DASA 1251-2-1 (AD 349123), 468 pp., August 1963. (SRD)

Part 2 - Plumbbob Through Hardtack (U), DASA 1251-2-2 (AD 329124), 456 pp., August 1963. (SRD)

Part 3 - Nougat Through Niblic (U), DASA 1251-2-3 (AD 371725), 226 pp., March 1966. (SRD)

Supplement, Foreign Nuclear Tests (U), DASA 1251 (AD 358417L), 77 pp., October 1964. (SRD)

Volume III, Annotated Compendium of Data on Physical and Chemical Properties of Fallout (U), DASA 1251-3 (AD 381963L), 770 pp., November 1966. (SRD)

Volume IV, Annotated Compendium of Data on Radiochemical and Radiation Characteristics of Fallout (U):

Part 1 - Specific Activity, Activity-Size Distribution, Decay (U), DASA 1251-4-1 (AD 500919L), 643 pp., September 1968. (SRD)

Part 2 - Radiochemical Composition, Induced Activity, Gamma Spectra (U), DASA 1251-4-2 (AD 523385), 570 pp., 31 May 1972. (SRD)

Volume V, Transport and Distribution of Local (Early) Fallout from Nuclear Weapon Tests (U), DASA 1251-5 (AD 362012), 580 pp., May 1965. (SRD)

- PC-2. Compilation of Local Fallout Data from Test Detonations 1945-1962 Extracted from DASA 1251, edited by H.A. Hawthorne of General Electric Tempo, DASIAC, for DNA, 1 May 1979:
- Volume 1, Continental U.S. Tests, DNA 1251-1-EX (AD A079309), 619 pp. (U)
- Volume 2, Oceanic U.S. Tests, DNA 1251-2-EX (AD A079310), 351 pp. (U)
- PC-3. Nuclear Cloud Dimensional Data (U), DASIAC SR-148, by H.A. Hawthorne, et al., of General Electric Tempo, DASIAC, for DNA:
- Volume 1, Underwater and Water-Surface Bursts (U) (DASIAC 23157, AD C004533), 56 pp., 3 September 1975. (CFRD)
- Volume 2, Underground, Ground Surface, and Low-Altitude Bursts (U) (DASIAC 28802, AD C021120), 208 pp., December 1978. (CFRD)
- PC-4. Nuclear Cloud Stem Data Analysis (U), DNA 3402F, by J.T. Powers of Science Applications, Inc. for DNA, 174 pp., 24 May 1974. (CFRD)
- PC-5. Nuclear Precursor Phenomenology and Sweep-Up Dust Cloud Model Development, DNA 3781F (AD B009947L), by R.T. Liner, et al., of Science Applications, Inc. for DNA, 200 pp., 4 November 1975. (U)
- PC-6. Nuclear Cloud Data and Predictive Uncertainties (U), DNA 5508F (AD C026949), by M. Rosenblatt, et al., of California Research and Technology, Inc. for DNA, 148 pp., 1 November 1980. (SFRD)
- PC-7. Above-Surface Phenomena Arising from Underwater Nuclear Explosions: Prediction of Dimensions and Overall Density Histories (U), NRDL-TR-68-113 (DASIAC 08359), B.T. Lee, Naval Radiological Defense Laboratory, 92 pp., 15 August 1968. (SFRD)
- PC-8. DNA Nuclear Dust Environment Symposium (U), Executive Summary (U), DNA 4867F, A.T. Hopkins and J.F. Moulton, DNA, 28 pp., October 1978. (C)
- PC-9. Nuclear Explosion Dust Cloud Phenomena--A Guide to the Literature (draft), DASIAC TN 85-3, by K.E. Gould of Kaman Tempo, DASIAC, for DNA, May 1985. (U)
- PC-10. Introduction to Nuclear Dust/Debris Cloud Formation, DNA 5832T (AD A114546), by M. Rosenblatt of California Research and Technology, Inc. for DNA, 48 pp., 1 July 1981. (U)
- PC-11. Dust from Low Altitude Bursts, JASON Technical Report JSR-81-30 (DASIAC 32141), D. Eardley and J. Katz, SRI International, 1611 North Kent Street, Arlington, VA 22209, 40 pp., March 1982. (U)
- PC-12. The History of Fallout Prediction (DASIAC 30929, AD 079560), J.C. Willis, U.S. Air Force Institute of Technology, Wright-Patterson AFB, OH, 29 pp., 1 June 1979. (U)

- PC-13. Fallout Prediction, Field Manual FM 3-22 (DASIAC 33955), Headquarters, Department of the Army, 80 pp., October 1973. (U)
- PC-14. DELFIIC: Department of Defense Fallout Prediction System, DNA 5159F-series (2 volumes), by H.G. Norment of Atmospheric Science Associates for DNA, 31 December 1979:
- Volume I, Fundamentals, DNA 5159F-1 (AD A088367), 100 pp. (U)
- Volume II, User's Manual, DNA 5159F-2 (AD 088512), 234 pp. (U)
- PC-15. Analysis and Comparison of Fallout Prediction Models (U), DNA 4569F (AD C018143), by H.G. Norment of Atmospheric Science Associates for DNA, 320 pp., 11 March 1977. (SRD)
- PC-16. Fallout: Its Characteristics and Management, AFRRRI TR83-5 (DASIAC 34641), K.P. Ferlic, Armed Forces Radiobiology Research Institute, Bethesda, MD 20814, 100 pp., December 1983. (U)
- PC-17. Radioactive Fallout from Nuclear Weapons Tests, Proceedings of a conference held in Germantown, MD, November 15-17, 1961, TID-7632 (2 volumes) (DASIAC 22759, 60), U.S. Atomic Energy Commission, 541 pp., published February 1962. (U)
- PC-18. Proceedings: Symposium on Intermediate Range Atmospheric Transport Processes and Technology Assessment, held at Gatlinburg, TN, October 1-3, 1980, CONF-801064 (DASIAC 31777), U.S. Department of Energy, 472 pp., published October 1981. (U)

SECTION 4

NUCLEAR WEAPON EFFECTS (E)

The three best known references for the effects of nuclear weapons on a broad spectrum of military and civilian targets are the Defense Nuclear Agency Capabilities of Nuclear Weapons (Reference E-1), the Defense Intelligence Agency Physical Vulnerability Handbook - Nuclear Weapons (Reference E-2), and the USA/USMC Staff Officers' Field Manual, Nuclear Weapon Employment Effects Data (Reference E-3). These references are often referred to as "EM-1," "AP-550," and "FM-101-31 (-1, -2, or -3)," respectively, in reference to their report numbers. Although widely used by nuclear effects analysts, each of these references has significant limitations.

AP-550 covers a broad variety of military and civilian targets but, with the exception of personnel, only for vulnerability to blast. Although AP-550 and EM-1 have been updated since their original publishing dates in 1969 and 1972, the changes have generally been minor. Both AP-550 and EM-1 vulnerability levels are based largely on out-of-date military equipment and systems and both generally give the 50-percent damage level rather than permitting a detailed statistical analysis. FM-101-31-2 provides tables of probabilities of damage for given targets at particular ranges and for other conditions when exposed to specific tactical weapons; i.e., weapon delivery error is inherently included. Because of these differences and the different methodologies employed, an analyst can get significantly different results when using each of these references for a particular set of conditions.

As mentioned in Section 2, software for hand-held calculators is available for weapons effects computations based on these references.

- E-1. Capabilities of Nuclear Weapons (U), DNA EM-1 (2 volumes), Defense Nuclear Agency, 1,200 pp., 1972, with changes through 1 August 1981. (SRD)
- E-2. Physical Vulnerability Handbook - Nuclear Weapons (U), AP-550-1-2-69-INT (DASIAC 24416, DTL 060717), Defense Intelligence Agency, 247 pp., June 1969 (with three changes through June 1976). (C)
- E-3. Staff Officers' Field Manual, Nuclear Weapon Employment Effects Data (U), FM-101-31-2 (USA), FMFM 11-4A (USMC) (DASIAC 26154), Department of the Army and Marine Corps Fleet Marine Force, approx. 500 pp, March 1977 (with Change 1). (SRD)

AEROSPACE SYSTEMS (EA)

The AFSCM 500-series of eight manuals (Reference EA-1) is the major comprehensive source of information on nuclear weapon effects on aerospace systems. Volume 1 is a summary of all aspects of nuclear weapon environments and their effects on air force systems. Other volumes address blast, Argus effect, ionizing radiations, optical and infrared, EMP, X rays, and ground structures. The volumes are infrequently updated.

Handbook for Analysis of Nuclear Weapon Effects on Aircraft, DNA 2048H (Reference EA-2), is exactly what the title implies. This unclassified handbook presents methods for analyzing blast gust and overpressure and thermal and nuclear radiation effects on aircraft and helicopters, and also the crew. However, the emphasis in this handbook is on blast and thermal effects. The other effects are included for completeness but the methodologies are unchanged from the previous 1970 version. A supplement included in the second volume describes computer programs for mechanizing the calculations. Reference EA-3 describes the operation of the CROM ACV-1 programmable calculator when applied to the methodologies of DNA 2048H. Reference EA-4 addresses the special case of vulnerability envelopes for supersonic aircraft.

Air Blast and Thermal Effects on Aircraft - Data Compendium (Reference EA-5) is a data compilation of nuclear blast and thermal environments and effects for in-flight and parked aircraft and aircraft structures and components. Reference EA-6 reevaluates and summarizes the data for only in-flight aircraft, with brief comments on the nature and extent of the damage observed. The Vulnerability of In-Flight Soviet Aircraft to Nuclear Weapon Blast Effects (Reference EA-7) analyzes the Backfire and Foxbat aircrafts. The DNA sourcebook on vulnerability and hardening of reentry vehicles is Nuclear Weapon Vulnerability Source Book (Reference EA-8), but the current publication is dated 1966. References EA-9 and EA-10 also relate specifically to vulnerability and hardening of reentry vehicles, but both are also fairly old (1971 and 1973). Review of Shielding Concepts (Reference EA-11) is a very readable summary of RV shielding concepts and materials. Reference EA-12 relates specifically to satellites and compiles the results of 16 years of nuclear effects testing of satellite materials and components. The Proceedings of the April 1982 Shock Physics Aerospace Systems Conference (Reference EA-13) summarize a variety of topics of current interest, including directed energy effects.

Electromagnetic Pulse Handbook for Missiles and Aircraft in Flight (Reference EA-14), although from 1972, is a comprehensive unclassified handbook of analytical and experimental techniques for assessing EMP response, vulnerability, and hardening.

Two basic DNA references for nuclear effects on PEP (propellants, explosives, and pyrotechnics) materials and systems are Sourcebook of Radiation Effects on Propellants, Explosives, and Pyrotechnics (Reference EA-15) and Proceedings of Fifth Symposium, Nuclear Survivability of Propulsion and Ordnance Systems (Reference EA-16). Although PEP materials are not limited to aerospace systems, this is the primary interest and focus of the references; therefore, they are included in this category of effects on aerospace systems.

See the other appropriate sections of this Guide for other references specifically related to aerospace electronics vulnerability and effects on USAF personnel.

EA-1. Systems Application of Nuclear Technology (U), AFSCM 500-series (8 volumes), Air Force Systems Command:

Nuclear Weapons Effects on Air Force Systems (U), AFSCM 500-1 (DASIAC 10556), 200 pp., April 1970. (SRD)

Blast Effects on Aerospace Vehicles (U), AFSCM 500-2 (DASIAC 02532), 100 pp., March 1964. (SRD)

ARGUS Phenomenon and Its Effects on Aerospace Systems (U), AFSCM 500-3 (DASIAC 02963), 160 pp., November 1964. (SRD)

Initial Radiation Calculations and Effects on Personnel (U), AFSCM 500-4 (DASIAC 02938), 30 pp., December 1964. (SRD)

Nuclear Weapon Optical-Infrared Phenomena and Their Effects on Air Force Systems (U), AFSCM 500-5 (DASIAC 07105), 120 pp., June 1968. (SRD)

Electromagnetic Pulse Effects on Air Force Systems (U), AFSCM 500-6 (DASIAC 12634), 600 pp., November 1971. (SRD)

X-Ray Effects on Air Force Systems (U), AFSCM 500-7 (DASIAC 26391), 200 pp., 15 October 1965. (SRD)

Effects of Air Blast, Ground Shock, and Cratering on Hardened Structures (U), AFSCM 500-8 (DASIAC 06117), 105 pp., March 1967. (U)

EA-2. Handbook for Analysis of Nuclear Weapon Effects on Aircraft, DNA 2048H-series, by Kaman Avidyne for DNA, 18 March 1976:

Volume 1, DNA 2048H-1 (AD B012992L), 538 pp. (U)

Volume 2, DNA 2048H-2 (AD B012993L), 576 pp. (U)

EA-3. Aircraft Vulnerability, DNA 2048H-1, CROM ACV-1, Reference Manual, HTI-SDR-80-128 (DNA 2048 1C), by Horizons Technology, Inc. for DNA, 352 pp., 17 March 1980. (U)

EA-4. Airblast Vulnerability Envelopes for Supersonic Aerospace Vehicles, AFWL-TR-78-187 (DASIAC 28446, AD A072247), G.M. Campbell, Air Force Weapons Laboratory, 30 pp., March 1979. (U)

EA-5. Air Blast and Thermal Effects on Aircraft - Data Compendium (U), DASIAC SR-168 (DASIAC 31100), E.L. Harner and D.A. Reitz of Kaman Tempo, DASIAC, for U.S. Army Ballistic Research Laboratory, 455 pp., December 1978. (CFRD)

- EA-6. Nuclear Test Data Base for In-Flight Aircraft (U), L-1613-80 (DASIAC 28611), J.F. Moulton, Jr., General Electric Tempo, 39 pp., 4 January 1980. (SRD)
- EA-7. The Vulnerability of In-Flight Soviet Aircraft to Nuclear Weapon Blast Effects (U), DNA 5014F (AD C022185), by N.P. Hobbs and K.R. Wetmore of Kaman Avidyne for DNA, 60 pp., 1 June 1979. (SFRD)
- EA-8. Nuclear Weapon Vulnerability Source Book (U), DASA 1464 (9 volumes), Defense Atomic Support Agency, Washington, D.C. 20301, 1,138 total pp., January 1966. (S)
- EA-9. Vulnerability and Hardening of Reentry Systems (U), AFWL-TR-71-73 (DASIAC 12279, AD 516973), H.F. Rizzo, et al., Air Force Weapons Laboratory, 146 pp., August 1971. (SRD)
- EA-10. Reentry Vehicle Lethality Criteria Studies (U), DNA 3128F (AD 527061), J.M. Gilmore, et al., of AVCO for DNA, 230 pp., 23 April 1973. (SRD)
- EA-11. Review of Shielding Concepts (U), DNA 3357D, J.W. Taylor, et al., Headquarters DNA, 86 pp., 2 February 1975. (SRD)
- EA-12. Handbook of Nuclear Effects on Satellite Materials (U), SAMSO TR-77-56 (DASIAC 25406, AD C010241L), by M.J. Treadaway, et al., of IRT Corp. for Space and Missile Systems Organization, 359 pp., 4 March 1977. (SRD)
- EA-13. Shock Physics Aerospace Systems Conference Proceedings (U), DNA-TR-82-30-series (2 volumes), J.I. Slaughter, editor, for Kaman Tempo and Defense Nuclear Agency, 30 September 1982:
- Volume 1 (U), DNA-TR-82-30-V1 (AD C033061), 766 pp. (SRD)
- Volume 2 (U), DNA-TR-82-30-V2 (AD C033062), 506 pp. (SRD)
- EA-14. Electromagnetic Pulse Handbook for Missiles and Aircraft in Flight, EMP Interaction 1-1, AFWL TR 73-68 (DASIAC 17420, AD 919395L), by Sandia Laboratories, Albuquerque, for the Air Force Weapons Laboratory, 520 pp., September 1972. (U)
- EA-15. Sourcebook of Radiation Effects on Propellants, Explosives, and Pyrotechnics, DNA 2881F-series (2 volumes), by H. Paitchel, et al., of Picatinny Arsenal for DNA:
- Volume I, DNA 2881F-1 (AD 916941L), 318 pp., 1 January 1974. (U)
- Volume II (on order).
- EA-16. Proceedings of Fifth Symposium, Nuclear Survivability of Propulsion and Ordnance Systems (U), DNA 4032P-series (3 volumes), by L. Avrami, et al., of Lockheed Missiles and Space Co. for DNA, October 1975:

Volume I, DNA 4232P-1 (AD C010807), 338 pp. (SRD)

Volume II, DNA 4232P-2 (AD C010808), 454 pp. (SRD)

Volume III, DNA 4232P-3 (AD C010809), 330 pp. (SRD)

NAVAL SYSTEMS (EN)

Vulnerability of Naval Forces to Nuclear Explosions (see Reference C-6) is a recent NWP that provides a handbook treatment of the effects of nuclear weapons phenomena on navy ships and submarines, equipment, personnel, and systems. The only other reference that might be considered a comprehensive handbook of nuclear effects on naval systems is Handbook of Underwater Nuclear Explosions (Reference EN-1). Volume 1 summarizes phenomenology; Volume 2 assesses effects on surface ships and submarines and their equipments and crews; and Volume 3 addresses effects on dams, harbors, and dockyard structures. Some of the chapters, however, are quite dated, ranging from 1963 to 1971. Also, Volume 2 treats only water shock in much detail. Since the section on airblast effects on surface ships was written in 1965, interested readers may find useful the Proceedings: DASA Conference on Sailor Hat (Reference EN-2), which was a 1965 series of three 1-KT nuclear equivalent high-explosive charges that exposed ships and ship equipment and structures to airblast up to 10 psi. (More recent high-explosive simulations have exposed a limited number of naval structures and equipment.)

Proceedings of the DASA Shock Physics Land and Naval Systems Long Range Planning Meeting (Reference EN-3) contains a number of pertinent papers on shock phenomena and response of ships and equipment, but the information is from 1971.

Effectiveness of Hardening Ships (Reference EN-4) uses a guided missile cruiser (CGN-38) as a model for detailed evaluation of susceptibility of navy combat ships to all nuclear effects. It makes recommendations for future ship hardening and discusses the expected consequences and costs. Reference EN-5 summarizes the findings of studies on the survivability of systems and personnel of DLGN-38 type ships. CG-47 Vulnerability to Nuclear Weapons (Reference EN-6) is a relatively recent but abbreviated study that may be of interest because it concisely summarizes the nuclear phenomena of naval concern and consolidates, in 26 tables for the various threat phenomena, vulnerability levels of the AEGIS combat system components. A Design Procedure for Deckhouses Resistant to Nuclear Blast and Thermal Loads (Reference EN-7) is a recent report on that subject.

Vulnerability of Soviet Submarines to Underwater Nuclear Bursts (Reference EN-8) is of interest primarily because it concisely describes the major methods used to predict impairment of seaworthiness, mobility, and weapon delivery systems for U.S. submarines. Response of Main Pressure Hull to Underwater Nuclear Shock Waves (Reference EN-9) describes a dynamic design-analysis method.

EMP Guidelines for Navy Ship Platform Hardening (Reference EN-10) is a very recent study on that subject.

See the other appropriate subsections of this Guide for additional references related to naval electronics vulnerability and effects on naval personnel.

EN-1. Handbook of Underwater Nuclear Explosions (U), DNA 1240H-series (5 parts), by General Electric Tempo, DASIAC, for Defense Nuclear Agency:

- Volume 1 - Part 1, DNA 1240H-1 (AD 520206), 826 pp., November 1971. (CFRD)
- Volume 1 - Part 2, DNA 1240H-1 (AD 520414), 636 pp., November 1971. (SRD)
- Volume 2 - Part 1, DNA 1240H-2 (AD 523834), 494 pp., March 1972. (CFRD)
- Volume 2 - Part 2, DNA 1240H-2 (AD 523835), 646 pp., March 1972. (SRD)
- Volume 3, DNA 1240H-3 (AD 520167), 844 pp., November 1971. (SRD)
- EN-2. Proceedings: DASA Conference on Sailor Hat, DASA 1775 (AD 373941), by General Electric Tempo, DASIAC, for Defense Nuclear Agency, 322 pp., May 1966. (U)
- EN-3. Proceedings of the DASA Shock Physics Land and Naval Systems Long Range Planning Meeting (U) (held 23-24 February 1971), DASIAC SR-124 (DASIAC 12287, AD 517042), by General Electric Tempo, DASIAC, for Defense Nuclear Agency, 558 pp., published August 1971. (SRD)
- EN-4. Effectiveness of Hardening Ships (U), NSWC/WOL TR 77-56, J.W. Downs, Naval Surface Weapons Center, White Oak, Silver Spring, MD 20910, 1 July 1977:
- Volume I, Executive Summary (DASIAC 26575, AD C013454L), 31 pp. (S)
- Volume II (DASIAC 26576, AD C013455L), 193 pp. (S)
- EN-5. Summary Report Project S48-14 Nuclear Warfare Survivability of Ships (U), NOLTR 74-145 (DASIAC 21575, AD C001179L), T.H. Jones and E.M. Thorn, Naval Ordnance Laboratory, White Oak, Silver Spring, MD 20910, 55 pp., 16 January 1975. (C)
- EN-6. CG-47 Vulnerability to Nuclear Weapons (U), NSWC TR 81-115 (DASIAC 31532, AD C026823), E.F. Kobee, Naval Surface Weapons Center, White Oak, Silver Spring, MD 20910, 191 pp., 1 February 1981. (SRD)
- EN-7. A Design Procedure for Deckhouses Resistant to Nuclear Blast and Thermal Loads (U), DNTSRDC-81/038 (DASIAC 32463, AD C027975), S-L. Wang and C. Ng, David W. Taylor Naval Ship R&D Center, Bethesda, MD 20084, 142 pp., April 1982. (C)
- EN-8. Vulnerability of Soviet Submarines to Underwater Nuclear Bursts (U), S-4492 (DASIAC 21364, AD 532140), W.R. Conley, Naval Ship R&D Center, Bethesda, MD 20084, 84 pp., August 1974. (S)
- EN-9. Response of Main Pressure Hull to Underwater Nuclear Shock Waves, Report 4533 (DASIAC 21640, AD B003555L), Y.F. Wang, et al., Naval Ship R&D Center, Bethesda, MD 20084, 43 pp., April 1975. (U)

EN-10. EMP Guidelines for Navy Ship Platform Hardening, IRT 82 117-037, Y. Shaw and L. Duncan, IRT Corporation, 15 February 1983. (U)

GROUND FORCES FIELD EQUIPMENT (EG)

Although it is quite dated (1971) and much of the information has been summarized into the current version of EM-1 (see Reference C-2), Study of Military Field Equipment Response to Air Blast and Prediction of Damage (Reference EG-1) can serve as a basic introduction to the subject. Volume I of Nuclear Weapons Effects on Army Tactical Systems (Reference EG-2) is a more recent and unclassified overview of nuclear weapon phenomena, effects on army tactical systems, and basic hardening methods. Volume II discusses important life-cycle events for the design, production, and deployment of nuclear-survivable equipments.

Analytical Assessment of Damage to Vehicles by Air Blast from Nuclear Weapons (Reference EG-3) describes a methodology that includes vehicle overturning, plate deflection and effect on internal components, and azimuthal variation of kill probability. Aerodynamic and Mass Modeling of Army Tracked Vehicles for Nuclear Blast Wave Response Codes (Reference EG-4) describes the mathematical modeling of army tracked vehicles for use with nuclear blast vehicle overturning codes and compares the various models. Damage Analysis of Selected Targets and Target Elements (Reference EG-5) briefly describes analytical techniques used to perform damage analyses on selected army missile systems and armored vehicles and gives summary results. Reference EG-6 compares blast and thermal damage distances versus weapon yield for army equipment types and personnel, as given by the basic predictive handbooks.

The results of nuclear and high-explosive blast testing of military field equipment have been summarized into major compilations for tanks and other armored vehicles (Reference EG-7), wheeled vehicles (Reference EG-8), and communications equipment (Reference EG-9). Each of these compilations includes descriptions of the airblast environments and the tested equipments, summary descriptions and quantification of damage and displacements, assessments of data quality and the damage classifications assigned, and pretest and posttest photographs.

Vulnerability Data Array: The Agreed Data Base - Final Report (Reference EG-10) is the culmination of the previous studies. This slim report provides a standard and unified source of vulnerability levels (statistical mean values and standard deviations) for all classes of current field equipment (and also for personnel). The Vulnerability Data Array is to be used in place of FM-101-31-2, DNA EM-1, and DIA AP-550, the well-known standard references. Similarly, Reference EG-11 specifies the nuclear weapon environments for blast, thermal, TREE, and low-altitude EMP that are to be used by (1) DARCOM laboratories to assess the vulnerability of tactical equipment in support of tactical warfare analyses and (2) tactical analysts in their damage-assessment computer codes.

See the other appropriate sections of this Guide for references regarding electronics vulnerability and effects on ground forces personnel.

EG-1. Study of Military Field Equipment Response to Air Blast and Prediction of Damage (U), DASA 2005-series (2 volumes), by P.J. Morris of URS Research Co. for DNA:

Volume I, DASA 2005-1, 182 pp., October 1971. (CFRD)

Volume II, DASA 2005-2, 217 pp., January 1972. (SFRD)

- EG-2. Nuclear Weapons Effects on Army Tactical Systems, HDL-TR-1882-series (2 volumes), J.J. Halpin, et al., Harry Diamond Laboratories, Adelphi, MD 20783:

Volume I, Overview, HDL-TR-1882-I (DASIAC 28270, AD A069672), 70 pp., April 1979. (U)

Volume II, Management, HDL-TR-1882-II (DASIAC 28823, AD A080402), 116 pp., May 1979. (U)

- EG-3. Analytical Assessment of Damage to Vehicles by Air Blast from Nuclear Weapons - Methodology (U), HDL-TR-1838 (DASIAC 26103), L.J. Belliveau, Harry Diamond Laboratories, Adelphi, MD 20783, 44 pp., December 1977. (C-NOFORN)
- EG-4. Aerodynamic and Mass Modeling of Army Tracked Vehicles for Nuclear Blast Wave Response Codes (U), HDL-TR-1874 (DASIAC 27772, AD C017783), L.J. Belliveau, Harry Diamond Laboratories, Adelphi, MD 20783, 56 pp., February 1979. (C)
- EG-5. Damage Analysis of Selected Targets and Target Elements (U), DNA 3682F (AD C005127), by J.V. Braddock, et al., of The BDM Corporation for DNA, 42 pp., 17 April 1975. (SFRD)
- EG-6. Predictions of Ranges of Blast Damage to Military Equipment and Thermal Radiation Effects on Personnel due to Explosions of Nuclear Weapons (U), BRL CR 204 (DASIAC 21646, AD C001653L), by R.W. Shnider of URS Research Co. for Ballistic Research Laboratory, Aberdeen Proving Ground, MD 21005, 52 pp., January 1975. (C)
- EG-7. Blast Damage to Tanks - Preferred Data Base (U), ARBRL-CR-00359 (DASIAC 26908, AD C015977L), by E.J. Bryant, et al., of General Electric Tempo, DASIAC, for Ballistic Research Laboratory, Aberdeen Proving Ground, MD 21005, 486 pp., March 1978. (CFRD)
- EG-8. Blast Damage and Displacements of Military Wheeled Vehicles (U), DNA 5579T-series (2 volumes), by E.J. Bryant, et al., of Kaman Tempo for DNA, 31 December 1979:
- Volume I, DNA 5579T-1 (AD C029869), 254 pp. (CFRD)
- Volume II, DNA 5579T-2 (AD C029870), 306 pp. (CFRD)
- EG-9. Blast Damage to Communications Equipment - Preferred Data Base (U), ARBRL-CR-00397 (DASIAC 27949), by E.J. Bryant, et al., of General Electric Tempo for Ballistic Research Laboratory, Aberdeen Proving Ground, MD 21005, 333 pp., April 1979. (C)

- EG-10. Vulnerability Data Array: The Agreed Data Base - Final Report (U), HDL-TR-1906 (DASIAC 29580, AD C022425), W.L. Vault, Harry Diamond Laboratories, Adelphi, MD 20783, 70 pp., July 1980. (S)
- EG-11. Nuclear Weapons Environments for Vulnerability Assessments to Support Tactical Nuclear Warfare Studies (U), HDL-TM-77-4 (DASIAC 26205), W.E. Sweeney, Jr., et al., Harry Diamond Laboratories, Adelphi, MD 20783, 46 pp., June 1977. (C)

STRUCTURES (ES)

The Air Force Manual for Design and Analysis of Hardened Structures (Reference ES-1) is a basic and comprehensive handbook on the subject. It covers the full range of weapons phenomena and effects, although radiation is not treated in depth. Approximately 500 pages are devoted to an extensive discussion of nuclear weapon phenomena. Emphasis in the manual is on basic understanding of phenomena and effects and on methods that are suitable for hand calculations. Volume 5 of Nuclear Geoplosics (Reference ES-2) is the DNA sourcebook on the effects of airblast and ground shock on underground structures, but the current version is dated 1964. Reference ES-3 is a recent literature survey on the response of equipments inside structures to ground shock.

Engineering Measures for Protection from Modern Means of Destruction (Reference ES-4) is a basic Russian handbook on protection of ground troops and field equipment from nuclear effects. It gives detailed instructions on construction of field fortifications.

Protective Construction (Reference ES-5) is a U.S. civil defense course text on the practical analysis and design of individual protective shelters. Reference ES-6 is a similar Russian text that provides architectural students with basic technical knowledge for sheltering populations in protective structures.

Reference ES-7 describes a probabilistic approach to design and testing and applies the method to the design of a tunnel liner. Reference ES-8 is a more recent description of stochastic modeling for structural damage. The separate appendix reviews fundamental concepts in probability and provides some examples of their application in structural dynamics, including a computer program listing. Physical Modeling Techniques for Missile and Other Protective Structures (Reference ES-9) is the collected papers from the April 1982 convention by the American Society of Civil Engineers.

Reference ES-10 is a recent technical review of the state of the art related to construction and survival of deep underground basing of strategic missiles.

- ES-1. The Air Force Manual for Design and Analysis of Hardened Structures, AFWL-TR-74-102 (DASIAC 24092, AD B004152L), by R.E. Crawford, et al., of Civil Nuclear Systems Corporation for the Air Force Weapons Laboratory, Kirtland AFB, NM 87117, 1,216 pp., October 1974. (U)
- ES-2. Nuclear Geoplosics: A Sourcebook of Underground Phenomena and Effects of Nuclear Explosions, Part Five - Effects on Underground Structures and Equipment, DASA 1285-(V) (AD 443589), by J.L. Merritt and N.M. Newmark of N.M. Newmark Associates for Defense Atomic Support Agency, 186 pp., May 1964. (U)
- ES-3. Equipment Response to Ground Shock (U) (draft report), DASIAC SR-200 (DASIAC 33730), by F.J. Allen of Kaman Tempo, DASIAC, for DNA, 77 pp., 23 May 1983. (C)

- ES-4. Engineering Measures for Protection from Modern Means of Destruction, AST-1640I-003-75 (DASIAC 24185, AD B009991L) (translated August 1975 from Russian for the U.S. Army Foreign Science and Technology Center, Charlottesville, VA 22901). 243 pp., 1974. (U)
- ES-5. Protective Construction, TR-20-(vol 4) (DASIAC 33374), Defense Civil Preparedness Agency (now FEMA), 320 pp., May 1977. (U)
- ES-6. Special Questions of Architectural Design (For Nuclear Warfare Conditions), FSTC-HT-262-78 (DASIAC 28745, AD B040745L), A.S. Il'yashev of the U.S.S.R. (translated June 1979 from Russian for U.S. Army Foreign Science and Technology Center, Charlottesville, VA 22901), 268 pp., 1977. (U)
- ES-7. Probabilistic Approach to the Design and Test of Hardened Facilities, DNA 4321F (AD A062334), by D.H. Merchant, et al., of the Boeing Aerospace Co. for DNA, 130 pp., 29 April 1977. (U)
- ES-8. Stochastic Models for Structural Damage, AFWL-TR-82-123-series (2 parts), by T. Paez and D. Morrison of University of New Mexico for the Air Force Weapons Laboratory, Kirtland AFB, NM 87117, May 1983:
- Part 1 of 2, AFWL-TR-82-123, Pt. 1 (DASIAC 33665), 123 pp. (U)
- Part 2 of 2, AFWL-TR-82-123, Pt. 2 (DASIAC 33666), 60 pp. (U)
- ES-9. Physical Modeling Techniques for Missile and Other Protective Structures (DASIAC 34022, AD A130314), papers submitted for presentation during the American Society of Civil Engineers National Spring Convention, Las Vegas, NV, 420 pp., April 1982. (U)
- ES-10. Deep Underground Technical Review - A State-of-the-Art Analysis, AFWL-TR-82-130-series (2 parts), M. Reed, et al., Air Force Weapons Laboratory, Kirtland AFB, NM 87117, March 1983:
- Part 1 of 2, AFWL-TR-82-130, Pt. 1 (DASIAC 33432), 124 pp. (U)
- Part 2 of 2, AFWL-TR-82-130, Pt. 2 (DASIAC 33433), 94 pp. (U)

EMP AND TREE (EE)

Electronics vulnerability has been a major area of analysis in recent years. Of the many reports on the subject, the DNA handbooks on TREE and EMP are most comprehensive.

By and large, the references cited in this Guide in the subsection on EMP environments and interaction also include basic information on effects. DNA EMP Awareness Course Notes (see Reference PE-1) is quite basic while the DNA EMP Handbook (see Reference PE-2) gives over 2,700 pages of comprehensive information on phenomena, interaction, and effects. The other references cited in that EMP subsection can also provide effects information.

Reference EE-1 is a more specialized handbook that provides formulas and data for evaluating coupling of the high-altitude EMP to electric power systems and to facilities served with commercial electric power. Reference EE-2 is the DNA handbook that describes preferred test procedures regarding EMP effects on components. Topics covered are experiment design, documentation, typical induced EMP transients, current injection testing, and the specific test procedures to evaluate the EMP behavior of each specific type of electronic component.

The APACHE Program was a major vulnerability/survivability program regarding EMP effects on Pacific Command C³ networks. APACHE is documented in many volumes of the DNA 4284 report series. Reference EE-3 of the series summarizes established engineering practices and devices for hardening communications facilities against penetrating EMP. The DNA EMP Engineering Handbook for Ground Based Facilities (Reference EE-4) is even broader, providing management and engineering information for all levels of personnel who have responsibility for EMP protection of new HEMP-protected facilities.

Evaluation of Methodologies for Estimating Vulnerability to Electromagnetic Pulse Effects (Reference EE-5) is a current review by the National Research Council.

DNA EMP Simulation and System Hardening Symposium (Reference EE-6) is the most recent documentation of such proceedings in the DASIAC collection and covers a broad range of topics of interest at that time (late 1980).

The DNA TREE Handbook, Design Handbook for TREE (Reference EE-7), is the basic and comprehensive reference for TREE. It contains guidelines and data useful to the engineer designing nuclear-survivable electronic systems. It is concerned primarily with application of hardened electronic devices in hardened circuit design. Physical principles and their application in the development of state-of-the-art devices are included only as required for a better understanding of the data. At the present time, this handbook is comprised of eight separately-bound chapters that were issued in 1978. Four other chapters that will complete the set are in preparation or review. These 12 chapters cover the nuclear environment, evaluation of equipment, circuit hardening, system hardening, design tests, hardness assurance, component response data, interaction of transient radiation with matter, and SGEMP.

Although it is fairly old, Reference EE-8 is a very readable and concise summary of TREE for the non-specialist. Reference EE-9 is a handbook of test procedures that have been designated as standards for TREE. It is primarily intended for personnel using simulation facilities. Reference EE-10 describes existing TREE simulation facilities. Reference EE-11 describes the techniques and methodology for designing and qualifying TREE-hardened army tactical systems, and Reference EE-12 summarizes results of testing specific army electronic equipments.

Two periodically published references on radiation effects are Journal of Radiation Effects, a recently-initiated classified journal on subjects of interest to DNA, and the IEEE Annual Conference on Nuclear and Space Radiation Effects, IEEE Transactions on Nuclear Science, a major symposium each summer with dozens of technical papers.

- EE-1. Electromagnetic-Pulse Handbook for Electric Power Systems, DNA 3466F, by E.F. Vance of Stanford Research Institute for DNA, 346 pp., 4 February 1975. (U)
- EE-2. EMP Preferred Test Procedures (Selected Electronic Parts), DNA 3286H (AD A039768), by J.E. Bridges, et al., of IIT Research Institute for DNA, 602 pp., February 1977. (U)
- EE-3. Engineering Practices and Devices for EMP Hardening of Communications Facilities, DNA 4284H-A-4, by A.L. Whitson and D.J. Barnes of SRI International for DNA, 118 pp., 1 April 1980. (U)
- EE-4. DNA EMP Engineering Handbook for Ground Based Facilities, 3-volume set prepared by Booz Allen & Hamilton Inc. for DNA, 1 November 1983 draft:
 - Volume I - Program Management (U)
 - Volume II - Design and Engineering (U)
 - Volume III - Facility Operation & Maintenance (U)
- EE-5. Evaluation of Methodologies for Estimating Vulnerability to Electromagnetic Pulse Effects, a report by the Committee on Electromagnetic Environment, Energy Engineering Board, National Research Council, National Academy Press, Washington, D.C., 111 pp., 1984. (U)
- EE-6. DNA EMP Simulation and System Hardening Symposium (U), DNA 5702P-series (3 volumes), edited by IIT Research Institute for DNA, 1 April 1981:
 - Volume I (U), DNA 5702P-1 (AD C027547), 336 pp. (SRD)
 - Volume II (U), DNA 5702P-2 (AD B066851L), 290 pp. (U)
 - Volume III (U), DNA 5702P-3 (AD B066852L), 432 pp. (U)
- EE-7. Design Handbook for TREE (U), DNA 1420H-series (12 volumes), edited by M.A. Espig of General Electric Tempo, DASIAC, for DNA, 1 December 1978:

Chapter 1 - Introduction (U), DNA 1420H-1 (AD C020622), 38 pp. (CFRD)

Chapter 2 - Nuclear Weapon Burst Environment (U), DNA 1420H-2 (AD C020623), 104 pp. (SRD)

Chapter 3 - (on hardening, not yet issued).

Chapter 4 - (on hardening circuit design techniques, not yet issued).

Chapter 5 - Hardened Component, Subsystem, and System Design (U), DNA 1420H-5 (AD C020624), 88 pp. (CFRD)

Chapter 6 - Design Testing (Experimental Validation) (U), DNA 1420H-6 (AD C020625), 34 pp. (C)

Chapter 7 - Hardness Assurance (U), DNA 1420H-7 (AD C020626), 72 pp. (C)

Chapter 8 - (on component response, not yet issued).

Chapter 9 - (on component response, not yet issued).

Chapter 10 - Radiation Interaction (U), DNA 1420H-10 (AD C020627), 94 pp. (C)

Chapter 11 - System Generated Electromagnetic Pulse (U), DNA 1420H-11 (AD C020628), 58 pp. (C)

Chapter 12 - Index, Symbols, and Glossary, DNA 1420H-12 (AD A081551), 40 pp. (U)

- EE-8. A Management Guide to Transient-Radiation Effects on Electronics (TREE) (U), DNA 2051H (AD 519756), by J.J. Kalinowski of Battelle for DNA, 106 pp., February 1970. (SRD)
- EE-9. TREE Preferred Procedures, Selected Electronic Parts, DNA 2028H (AD A134722), edited by M.A. Espig of Kaman Tempo, DASIAC, for DNA, 208 pp., 31 January 1982. (U)
- EE-10. TREE Simulation Facilities, Second Edition, DNA 2432H (AD A085817), by J.V. Rosenfeld of General Electric Tempo, DASIAC, for DNA, 600 pp., 1 January 1979. (U)
- EE-11. Design Guidelines for Transient Radiation Effects on Tactical Army Systems, HDL-CR-81-015-1 (DASIAC 31395), by M. Rose, et al., of IRT Corporation for Harry Diamond Laboratories, Adelphi, MD 20783, 293 pp., July 1981. (U)
- EE-12. TREE Vulnerability Summary: Army Electronic Equipment (U), HDL-PR-83-3 (DASIAC 34551, AD C032390L), P.A. Trimmer, Harry Diamond Laboratories, Adelphi, MD 20783, 56 pp., June 1983. (C)

C³ SYSTEMS AND THE ATMOSPHERE (EC)

There are a number of major DNA references for nuclear burst effects on the atmosphere and the resulting effects on EM signal propagation. Reaction Rate Handbook (Reference EC-1) reviews, in the light of their utilization in atmospheric and ionospheric modeling applications, the chief theoretical methods involved in calculations of electronic structure, radiative process, dissociative recombination, and atomic and molecular scattering. Reference EC-2 is a pocket-sized extract of information, mostly from the Reaction Rate Handbook. The Trapped Radiation Handbook (Reference EC-3) is a comprehensive treatment of trapped radiation phenomena. It covers the fundamental physics and observational aspects of natural trapped radiation belts, the process of formation of natural and artificial radiation belts, and auxiliary related topics. It treats effects on spacecraft materials and devices in less depth and the discussion of spacecraft vulnerability is very sketchy. The third major reference for nuclear effects on the atmosphere is the Electromagnetic Blackout Handbook (Reference EC-4). It provides source material on pertinent nuclear weapon phenomenology, atmospheric processes, and effects of disturbed atmospheric environments on EM propagation, for use in analysis of radar and communication systems. Aids for the Study of Electromagnetic Blackout (Reference EC-5) is an unclassified compendium of selected graphs, charts, equations, and relations that are useful in the analysis of blackout. Reference EC-6 is a recent and concise review of the time history of a high-altitude burst as it pertains to EM signal propagation.

In addition to these references that are primarily phenomenology handbooks, there are several references that focus on effects of a disturbed atmosphere on EM signal propagation. The effects of nuclear bursts on the propagation of VLF and LF, HF, and satellite and scatter communications are described in References EC-7, EC-8, and EC-9, respectively. In each case, the first volume of these handbooks describes the effects for selected weapon and system parameters and the second volume provides general prediction techniques for arbitrary weapon and system parameters. (Reference EC-10 gives corrections to these handbooks.) Unfortunately, References EC-7 through EC-9 are relatively old; EC-9 is especially outdated for satellites. More recent summaries of propagation degradation effects are Reference EC-11 for BMD radar systems, Reference EC-12 for communication and navigation systems, and Reference EC-13 for satellite systems.

Other references include, in addition to effects on propagation, direct nuclear effects on C³ systems. (See also Reference EG-9 for a compendium of blast damage to Army C³ systems.) Executive Handbook of Nuclear Weapons Effects for C³ Systems (Reference EC-14) gives a concise summary of the various nuclear effects and response of C³ elements, brief examples of performance degradation of C³ systems, and summary discussions of measures that may improve C³ survivability. Reference EC-15 is a briefing text and slides (designed for a 3-hour course presentation) that covers these same topics in a more tutorial and basic manner. TNW C³ Vulnerability and Survivability Issues (Reference EC-16) is a relatively recent summary of that subject, while Reference EC-17 is a compendium (in 1979) of assessments related to the Theater Nuclear Warfare Safety and Survivability C³ program (TNFS²C³).

Until recently, the ROSCOE computer code was the "laboratory standard" for evaluating nuclear effects on radar and optical sensors. The code is described in many volumes of the ROSCOE Manual, but the description is summarized in Reference EC-18. Reference EC-19 is a brief introduction to the NORSE code, which has replaced ROSCOE as the laboratory standard.

EC-1. Reaction Rate Handbook, DNA 1948H, by H.H. Michels, et al., of General Electric Co. for DNA, 1,192 pp., 1972 (with Revision 8, April 1979). (U)

EC-2. A Pocket Manual of the Physical and Chemical Characteristics of the Earth's Atmosphere, DNA 3467H, by C.A. Blank, et al., of General Electric Co. for DNA, 282 pp., 1 July 1974. (U)

EC-3. The Trapped Radiation Handbook, DNA 2524H (AD 738841), by J.B. Cladis, et al., of Lockheed Palo Alto Research Laboratory for DNA, 732 pp., December 1971 (with Change 5, 21 January 1977). (U)

EC-4. Electromagnetic Blackout Handbook (U), Third Edition, DNA 3380H-series (3 volumes), W.S. Knapp, et al., of General Electric Tempo for DNA, 1 September 1974:

Volume I - Introduction to Nuclear Weapon Effects, Weapon Outputs, and Phenomenology of Heated Regions (U), DNA 3380H-1, 492 pp. (SRD-CNWDI)

Volume II - Atmospheric Ionization and Electromagnetic Propagation Effects (U), DNA 3380H-2, 414 pp. (SRD-CNWDI)

Volume III - Appendixes (U), DNA 3380H-3, 264 pp. (CFRD)

EC-5. Aids for the Study of Electromagnetic Blackout, DNA 3499H (AD A010228), W.S. Knapp and K. Schwartz of General Electric Tempo for DNA, 212 pp., 25 February 1975. (U)

EC-6. The Phenomenology of a High-Altitude Nuclear Explosion - A Comprehensive Review (U), DNA-TR-82-32, edited by D.R. McDaniel of SRI International for DNA, 150 pp., 2 July 1982. (SRD)

EC-7. Nuclear Effects on VLF and LF Communication Systems (U), DASA 1954-series (2 volumes), Defense Atomic Support Agency:

Volume 1, Selected Examples (U), DASA 1954-1 (AD 392160L), 210 pp., June 1968. (CFRD)

Volume 2, General Prediction Techniques (U), DASA 1954-2 (AD 394550L), 384 pp., September 1968. (C)

EC-8. Nuclear Effects on HF Communication Systems (U), DASA 1955-series (2 volumes), Defense Atomic Support Agency:

Volume 1, Selected Examples (U), DASA 1955-1, 348 pp., October 1967. (C)

Volume 2, General Prediction Techniques (U), DASA 1955-2, 352 pp., April 1968. (CFRD)

- EC-9. Nuclear Effects on Satellite and Scatter Communication Systems (U), DASA 1956-series, Defense Atomic Support Agency:

Volume 1, Selected Examples (U), DASA 1956-1 (AD 390254), 436 pp., October 1967. (CFRD)

Volume 1: General Techniques for Satellite Systems (U), DASA 1956-1 (formerly 1956-2), 378 pp., July 1968. (CFRD)

Volume 2: General Prediction Techniques for Scatter Systems (U), DASA 1956-2, 468 pp., October 1968. (CFRD)

- EC-10. Corrections to DASA Communication Handbooks (DASA 1954, 1955, 1956), DASA 2313, General Electric Tempo for Defense Atomic Support Agency, 31 pp., July 1969. (U)
- EC-11. Summary of BMD Radar Systems Degradation in a Nuclear Environment (U), DNA 3673H (AD C003517), by W.S. Knapp and K. Schwartz of General Electric Tempo for DNA, 70 pp., 15 July 1975. (C)
- EC-12. Summary of Communication and Navigation Systems Degradation in a Nuclear Environment (U), DNA 4890H (AD C019334), by W.S. Knapp of General Electric Tempo for DNA, 96 pp., 31 May 1979. (C)
- EC-13. A Reasonable Worst Case Specification of Nuclear Disturbed Radio Signals (U), DNA-IR-82-01 (AD C029241), in-house DNA report by L.A. Wittwer, et al., 100 pp., 4 April 1982. (SFRD)
- EC-14. Executive Handbook of Nuclear Weapons Effects for C³ Systems (U) (draft report), DASIAC TN 82-3 (DASIAC 33006), by F.N. Wimenitz of Kaman Tempo, DASIAC, for DNA, 52 pp., September 1983. (C)
- EC-15. Joint Command, Control and Communications (C³) Staff and Operations Course (U), Nuclear Weapons Effects, Nuclear Response & Survivability, Syllabus & Lecture Script (U) (DASIAC 27675), by General Electric Tempo for the Armed Forces Staff College and DNA, 175 pp., 1 October 1978 (being updated). (S)
- EC-16. TNW C³ Vulnerability and Survivability Issues (U), DNA 5589F (AD C028372), by A.L. Whitson and W.E. Jaye of SRI International for DNA, 160 pp., 1 January 1981. (S)
- EC-17. DOD Theater Nuclear Forces Survivability and Security (TNFS²): Compendium of Assessments Related to TNFS²C³ Program (U), DNA 5040T-series (2 volumes), by R.J. Carlin, et al., of The BDM Corporation for DNA, 31 December 1979:

Volume I (U), DNA 5040T-1 (AD A083328), 30 pp. (U)

Volume II (U), DNA 5040T-2 (AD C021114), 184 pp. (SFRD)

- EC-18. The ROSCOE Manual, Volume I-1 - Program Description, DNA 3964F-1-1 (AD A092917), by J.R. Garbarino of General Research Corporation for DNA, 124 pp., 29 February 1980. (U)
- EC-19. NORSE: A Brief Introduction to the Nuclear Optical and Radar Systems Effects Code, DNA 3964F-100, by J.G. Devore, et al., of Kaman Tempo for DNA, February 1983. (U)

PERSONNEL (EP)

Reports detailing the effects of nuclear explosions upon humans form a portion of the normal medical literature detailing human response to blast, burns, or ionizing radiation. The Index Medicus is the major bibliographic source in this field.

Nuclear effects on military personnel are often included in the major references for effects on military systems, where entire man-machine systems can be assessed. For the Army, however, there are several pertinent references specifically for effects on personnel. Personnel Risk and Casualty Criteria for Nuclear Weapons Effects (Reference EP-1) is the major such reference. It presents and analyzes biological response data to nuclear effects and develops casualty criteria for Army personnel. Report of the Defense Nuclear Agency Working Group on Nuclear Radiation Effects on Ground Combat Units (Reference EP-2) focuses on nuclear radiation effects on personnel. Nuclear Protection for the Soldier (Reference EP-3) is a more recent study by the ad hoc committee of the Army Scientific Advisory Panel. Initial Human Response to Nuclear Radiation (Reference EP-4) develops models of human response to radiation as the first phase of an investigation into the effects on military troop performance.

Navy Personnel Vulnerability to Nuclear Weapons (Reference EP-5) briefly summarizes vulnerability levels and potential survivability enhancements for Navy personnel. Source references are cited and the results are conveniently shown for various situations as curves of damage criteria versus distance and weapon yield.

Comparative Nuclear Effects of Biomedical Interest (Reference EP-6) summarizes selected physical and biological data bearing on the environmental variations caused by nuclear explosions and biological response. Although this study was in 1961, there does not seem to be any more recent comparable summary. The Biodynamics of Airblast (Reference EP-7) is the basic reference on biological effects of airblast-induced pressures, whole body translation, and missiles and debris. "Blast Biophysics; Past, Present, and Future," (Reference EP-8) is a more recent and condensed summary.

Manual of Medical Questions Relating to Protection from Radiation (Reference EP-9) is a Soviet survey of that aspect. Combined Injury Caused by Nuclear Explosions (Reference EP-10) presents the German viewpoint on the subject. Medical Effects of Nuclear Weapons, A Course for Military Physicians (Reference EP-11) is a recently published course book that covers all medical aspects, but that especially emphasizes ionizing radiation injuries. The proceedings of a 1981 U.S./Allied symposium (Reference EP-12) deals exclusively with ionizing radiation effects. The Pathophysiology of Combined Injury and Trauma (Reference EP-13) is the proceedings of the 1983 First International Symposium on the subject. The 29 research papers address combined injury (blast, thermal, and radiation) and trauma, immunology and inflammatory responses, and sepsis (a poisoned state from bacterial infections that enter the blood stream). The text requires readers knowledgeable on medical terminology.

References that pertain primarily to effects on civilian populations in general are discussed in the following subsection.

- EP-1. Personnel Risk and Casualty Criteria for Nuclear Weapons Effects (U), ACN 4260 (DASIAC 17827, AD 516440), United States Army Combat Developments Command, 332 pp., 2 August 1971. (C)
- Addendum to Personnel Risk and Casualty Criteria for Nuclear Weapons Effects, ACN 22744 (DASIAC 23553, AD B011629L), A.S. Warshawsky and C.N. Davidson, U.S. Army Nuclear Agency, 38 pp., March 1976. (U)
- EP-2. Report of the Defense Nuclear Agency Working Group on Nuclear Radiation Effects on Ground Combat Units (U), DNA 4143D (AD C009328), by C.A. McDonald, Jr., and H.L. Brode for DNA, 192 pp., September 1976. (C)
- EP-3. Nuclear Protection for the Soldier, Final Report of the Ad Hoc Committee of the Army Scientific Advisory Panel, 1977 (DASIAC 28677, AD A073849), by C.J.D. Zarafonitis, et al., 137 pp., 27 July 1979. (U)
- EP-4. Initial Human Response to Nuclear Radiation, DNA-TR-81-237 (AD A137543), by G.H. Anno, et al., of Pacific-Sierra Research Corp. for DNA, 92 pp., 1 April 1982. (U)
- EP-5. Navy Personnel Vulnerability to Nuclear Weapons (U), DNA 5046F (AD C021247), by A. Vitello and J. Morgan of The BDM Corporation for DNA, 32 pp., 31 December 1979. (C)
- EP-6. Comparative Nuclear Effects of Biomedical Interest, CEX-58.8, C.S. White, et al., of Lovelace Foundation for Medical Education and Research for Civil Effects Test Operations, U.S. Atomic Energy Commission, 83 pp., 11 January 1961. (U)
- EP-7. The Biodynamics of Airblast, DNA 2738T, by C.S. White, et al., of Lovelace Foundation for Medical Education and Research for DNA, 139 pp., July 1971. (U)
- EP-8. "Blast Biophysics; Past, Present, and Future," D.R. Richmond, et al., Lovelace Biomedical and Environmental Research Institute, paper in Proceedings of the Misisauga Bluff Phase II Results Symposium, 27-29 March 1979, Volume III, POR 7013-3, Field Command, DNA, Kirtland AFB, NM 87115, pp. 7-1 through 7-54, 26 September 1979. (U)
- EP-9. Manual of Medical Questions Relating to Protection from Radiation, FTD-ID(RS)T-1509-77 (DASIAC 30565, AD B024572L), by L.A. Il'in, et al., of the U.S.S.R. (translated 26 September 1977 from Russian for the Foreign Technology Division, Wright-Patterson AFB, OH), 124 pp., 1975. (U)
- EP-10. Combined Injury Caused by Nuclear Explosions, LF-TR-123 (DASIAC 29545), O. Messerschmidt, Technical University of Munich, West Germany (translated May 1976 from German for the Lovelace Biomedical and Environmental Research Institute, Albuquerque, NM), 102 pp., no date. (U)
- EP-11. Medical Effects of Nuclear Weapons, A Course for Military Physicians (DASIAC 33622, AD B072075), prepared by Armed Forces Radiobiology Research Institute, Bethesda, MD, approx. 200 pp., March 1983. (U)

- EP-12. Symposium on Biological Effects of Nuclear Weapons (U): Proceedings - Technology Liaison Group 3 (U), DASIAC SR-198 (DASIAC 33790), edited by W.E. Rogers of Kaman Tempo, DASIAC, for DNA, 246 pp., 1 June 1982. (U-Foreign Government Information)
- EP-13. The Pathophysiology of Combined Injury Trauma, Proceedings of the First International Symposium held April 27-29, 1983 at the Uniformed Services University of the Health Sciences, Bethesda, MD, edited by R.I. Walker, et al., for the Armed Forces Radiobiology Research Institute, Bethesda, MD 20814, 494 pp. (U)

CIVILIAN SECTOR AND THE ENVIRONMENT (ECE)

Some of the references in the previous subsection about effects on personnel also apply for general civilian populations. A good overview of nuclear weapon effects on the civilian sector is The Effects of Nuclear Weapons (see Reference C-1), which summarizes effects on the populations, property, and infrastructures of Hiroshima and Nagasaki and also effects on civilian targets exposed in the atmospheric nuclear test program. FEMA Attack Environment Manual (Reference ECE-1) is a broad simple discussion of nuclear weapon phenomena and effects of interest to civil defense planners. It is being released as nine individual chapters.

There have been many studies of the casualties and damage at Hiroshima and Nagasaki. The primary source documents for such studies are two three-volume reports by the U.S. Strategic Bombing Survey (References ECE-2 and ECE-3), a seven-volume report by the USN Bureau of Yards and Docks (Reference ECE-4), and a six-volume report on the medical effects (Reference ECE-5). Medical Effects of the Atomic Bomb in Japan (Reference ECE-6) is a manageable summary of Reference ECE-5. Because of the chaotic conditions following the bombings, the time lapse before the surveys were undertaken, and the lack of much pertinent information, all of these surveys include many uncertainties and biases and are subject to different interpretations. Nuclear Casualty Data Summary (Reference ECE-7) summarizes much previous work and presents a best estimate of Japanese casualties versus distance as functions of type of nuclear phenomena and various shielding categories.

An Interim Report on Collateral Damage (Reference ECE-8) develops civilian injury and fatality functions for various weapon yields, HOBs, and sheltering conditions. It also evaluates the important uncertainties of weapon environments, shelters, and biomedical response. Airblast Collateral Damage - Data Analysis (Reference ECE-9) compiles the available empirical data (primarily from analysis of References ECE-2 through ECE-6) on airblast effects on buildings, civilian populations, public utilities, and transportation systems, and develops parametric damage curves and threshold damage levels. Literature Survey of Blast and Fire Effects of Nuclear Weapons on Urban Areas (Reference ECE-10) cites 850 references in a concise and recent coverage of the last 30 years of research.

There have been many studies on national and global effects of nuclear war, but some are especially noteworthy because they were conducted by or for authoritative public agencies and are well known and available to the interested public. The Effects of Nuclear War (Reference ECE-11), prepared for the U.S. Senate, is perhaps the most significant of such studies. It addresses, in summary fashion, direct and indirect effects on both the U.S. and the U.S.S.R. for three attack cases. Attacks on single U.S. and Soviet cities are used to illustrate prompt nuclear effects, civil defense is discussed, and long-term and global effects are briefly mentioned. A range of casualty levels is given for the various scenarios. A different report with the same title (Reference ECE-12) is a much more concise summary while Reference ECE-13 is a brief survey of the effectiveness of civil defense in general war; both are by the U.S. Arms Control and Disarmament Agency. An article entitled "Limited Nuclear War" in Scientific American (Reference ECE-14) is also of interest because of its relatively large audience.

Reference ECE-15 summarizes and compares the various damage assessment computer codes for populations and facilities. It also summarizes effects, such as fires, radiation intake, etc., that are not usually included in such damage assessments.

Long-Term Worldwide Effects of Multiple Nuclear-Weapons Detonations (Reference ECE-16) is a comprehensive study by the National Academy of Sciences on the effects of a major nuclear exchange on the earth's atmosphere and geophysical processes and the direct and indirect effects on land and aquatic environments and on humans. This major work considers all the concerns expressed by numerous earlier studies. Since the NAS study, however, new findings (first published in Reference ECE-17) indicate that even a relatively small nuclear exchange might cause catastrophic climate changes. This "nuclear winter" issue is being intensely examined but the results of these studies are yet to be summarized or published.

Civil Defense (Reference ECE-18) can be considered the Soviet handbook on the subject. It presents all aspects of the Soviet civil defense under one cover; its focus is rural, however, because evacuation of urban areas is a key concept of Soviet plans. Reference ECE-19 is a relatively recent evaluation of Soviet programs and measures to protect Soviet industry. Industrial Survival and Recovery After Nuclear Attack (Reference ECE-20) evaluates Soviet methods for protecting industry and the feasibility of hardening selected Boeing industrial facilities. Reference ECE-21 includes, among other topics, vulnerability (blast levels versus damage and recovery times) for industrial equipments.

U.S. civil defense guidance is summarized in the booklet, Protection in the Nuclear Age (Reference ECE-22). Emergency Preparedness: A Handbook for Families (Reference ECE-23) gives additional self-help guidance. Radiological Defense Manual (Reference ECE-24) is designed as a student textbook for radiological defense courses. There are numerous references for the design of blast and radiation shelters, mostly for the 1960's. Nuclear War Survival Skills (Reference ECE-25) covers everything from soup to nuts on surviving a nuclear war by self-help measures. Reference ECE-26 is the most current documentation of conference proceedings, that have been held almost annually since 1962, on the general subject of blast and fire effects of interest to civil defense.

- ECE-1. FEMA Attack Environment Manual, CPG 2-1A-series (to be issued as 9 individual chapters), Federal Emergency Management Agency. (U)
- ECE-2. The Effects of the Atomic Bomb on Hiroshima, Japan (3 volumes) (DASIAC 22463, 22464, and 22465), The United States Strategic Bombing Survey, Physical Damage Division, 1,171 pp., May 1947. (U)
- ECE-3. The Effects of the Atomic Bomb on Nagasaki, Japan (3 volumes) (DASIAC 22460, 22461, 22462) The United States Strategic Bombing Survey, Physical Damage Division 1,082 pp., June 1947. (U)
- ECE-4. Report of the Bureau of Yards and Docks Mission to Japan 1945 (7 volumes) (DASIAC 22838 through 22844), USN Bureau of Yards and Docks, circa 1,100 pp., June 1946. (U)

- ECE-5. Medical Effects of Atomic Bombs: The Report of the Joint Commission for the Investigation of the Effects of the Atomic Bomb in Japan, NP-3036 through NP-3041 (6 volumes) (DASIAC 25937 through 25942), A.W. Oughterson, et al., Office of the Air Surgeon, Army Institute of Pathology, U.S. Atomic Energy Commission, Oak Ridge, TN, 1,725 pp., 19 April 1951. (U)
- ECE-6. Medical Effects of the Atomic Bomb in Japan, First Edition, A.W. Oughterson and S. Warren, editors, McGraw-Hill Book Company, Inc., 1956. (U)
- ECE-7. Nuclear Casualty Data Summary, DNA 5427F, by D.L. Summers of the Dike-wood Corporation for DNA, 128 pp., 29 August 1980. (U)
- ECE-8. An Interim Report on Collateral Damage, DNA 4734Z (AD A071371), by M.K. Drake, et al., of Science Applications, Inc. for DNA, 496 pp., October 1978. (U)
- ECE-9. Airblast Collateral Damage - Data Analysis, DASIAC SR-165 (DASIAC 34710), by K.E. Gould, et al., of Kaman Tempo, DASIAC, for DNA, 368 pp., January 1984. (U)
- ECE-10. Literature Survey of Blast and Fire Effects of Nuclear Weapons on Urban Areas, UCRL-53340 (DASIAC 33710, AD A123684), by T.A. Reitter, et al., of Lawrence Livermore National Laboratory for Federal Emergency Management Agency, Washington, D.C. 20472, 103 pp., June 1982. (U)
- ECE-11. The Effects of Nuclear War, OTA-NS-89 (DASIAC 28450, PB 296946), Office of Technology Assessment, Congress of the United States, 150 pp., May 1979. (U)
- ECE-12. The Effects of Nuclear War (DASIAC 28580, AD A072246), U.S. Arms Control and Disarmament Agency, Washington, D.C. 20451, 26 pp., April 1979. (U)
- ECE-13. An Analysis of Civil Defense In Nuclear War (DASIAC 27748, AD A062675), U.S. Arms Control and Disarmament Agency, Washington, D.C. 20451, 25 pp., December 1978. (U)
- ECE-14. "Limited Nuclear War," S.D. Drell and F.V. Hippel, Scientific American, Volume 235, Number 5, pp. 27-37, November 1976. (U)
- ECE-15. Ballistic Missile Defense for U.S. National Survival and Recovery. Volume XII - A Review of Damage Assessment Codes for Estimating Facility Destruction and Population Fatalities, SAI-79-816-HU (DASIAC 28080, AD B034988L), by E.J. Swick of Science Applications, Inc. for Ballistic Missile Defense Systems Command, Huntsville, AL 35807, 74 pp., January 1979. (U)
- ECE-16. Long-Term Worldwide Effects of Multiple Nuclear-Weapons Detonations (DASIAC 33476, PB-279976), National Academy of Sciences, Washington, D.C., 227 pp., October 1975. (U)

- ECE-17. "Nuclear Winter: Global Consequences of Multiple Nuclear Explosions," R.P. Turco, et al., pp. 1,283-1,292, and "Long-Term Biological Consequences of Nuclear War," P.R. Ehrlich, pp. 1,293-1,300, Science, Vol. 222, No. 4630, 23 December 1983. (U)
- ECE-18. Civil Defense, ORNL-TR-2306 (DASIAC 15457), N.I. Akimov, et al., Kolos, Moscow (translated April 1971 from Russian by Oak Ridge National Laboratory), 338 pp., 1969. (U)
- ECE-19. Soviet Civil Defense Concepts, Programs and Measures for the Protection of Industry in Nuclear War Conditions (DASIAC 32051, AD 102179), by L. Goure, et al., of Advanced International Studies Institute for Federal Emergency Management Agency, Washington, D.C. 20472, 168 pp., June 1981. (U)
- ECE-20. Industrial Survival and Recovery After Nuclear Attack, D180-20236-1 (DASIAC 25962), A Report to the Joint Committee of Defense Production U.S. Congress by The Boeing Aerospace Co., Seattle, Washington, 120 pp., 18 November 1976. (U)
- ECE-21. Industrial Protection Guide, Crisis Relocation Industrial Hardening Plan, SSI 8011 (10 booklets) (DASIAC 31548), by Scientific Service, Inc. for Federal Emergency Management Agency, June 1981. (U)
- ECE-22. Protection in the Nuclear Age, H-20 (DASIAC 33481), Defense Civil Preparedness Agency and Department of Defense booklet, 68 pp., February 1977. (U)
- ECE-23. Emergency Preparedness: A Handbook for Families, EMW-C-0297 (DASIAC 33415, AD A116689), by J.R. Christiansen and R.H. Blake of Brigham Young University for Federal Emergency Management Agency, Washington, D.C. 20472, 406 pp., June 1982. (U)
- ECE-24. Radiological Defense Manual, CPG2-6.2 (DASIAC 33368), Defense Civil Preparedness Agency and Department of Defense, 198 pp., June 1977. (U)
- ECE-25. Nuclear War Survival Skills, ORNL-5037 (DASIAC 33486), C.H. Kearney, Oak Ridge National Laboratory, Oak Ridge, TN 37830, 254 pp., September 1979. (Available from U.S. Government Printing Office: 1979-640-079/201). (U)
- ECE-26. Proceedings: 17th Asilomar Conference on Fire and Blast Effects of Nuclear Weapons, held May 30 - June 3, 1983, CONF-8305107 (DASIAC 34339, AD A132780), edited by R.G. Hickman and C.A. Meier of Lawrence Livermore National Laboratory for Federal Emergency Management Agency, Washington, D.C. 20472, 287 pp., July 1983. (U)

SECTION 5

SPECIAL REFERENCE MATERIALS (R)

A number of documents and publications can be considered as basic reference materials to particular areas related to nuclear weapons phenomena and effects. Some of the most useful and comprehensive of these research tools are listed in this section.

Test Information Index, HQDNA 119M, is an index of information recorded in the DNA Report of Nuclear Tests (DASA 12xx series, HQDASA 170M series, and HQDNA 170M series). This index gives event and program names, event date, device type, test yield, test purposes, and reference location for all U.S. nuclear tests. Reference R-1 is the current version of this infrequently updated index.

DOD Nuclear Weapons Effects Test Summary, DNA 625D (Reference R-2), summarizes the overall objectives, results, and engineering aspects of all of the nuclear weapon effects tests (since 1962) sponsored by the DOD and the DOE in the underground test program. It also summarizes the objectives and results of the individual experiments and gives references for details.

Underground Test Experiment Catalog, DNA 2941F-series, is a six-volume set of information on items exposed in nuclear underground tests. The catalog (Reference R-3) briefly describes test items and experiment designs and identifies where information for each experiment can be found, but it does not include test results. Each volume is independent of the others and all six are required for a complete catalog of tested items.

Reference R-4 is a catalog of DNA-sponsored computer codes that are still in current use or of some interest. The present version, which describes nearly 300 codes on one-page summary forms, is scheduled to be updated.

Reference R-5 is an unclassified glossary of terms and acronyms used in the variety of disciplines related to nuclear weapon phenomena and effects. It is intended primarily for generalists or for specialists confronted with terms outside their specialty and is an attempt to bring some standardization of language to the diverse nuclear weapon effects community by consolidating definitions from the most authoritative and widely-used references, such as JCS Pub 1, TP 4-1, and EM-1.

Index of Nuclear Weapon Effects Simulators (Reference R-6) gives one- to two-page summary descriptions of radiation, blast and shock, EMP and thermal simulators within the United States.

As authorized by DNA, DASIAC surveys its own collection and other information centers and prepares formal bibliographies on subjects of interest. Examples of such bibliographies include the Aerospace Vulnerability Bibliography, which is prepared and published intermittently and includes report abstracts,

and Naval Theater Nuclear Warfare Bibliography for PM-23, a recent compilation that cites approximately 1,700 references from DASIAC and other DOD collections. In addition to these relatively large and formal bibliographies, DASIAC has a collection of hundreds of informal bibliographies tailored to the specific requests of DOD agencies and qualified contractors.

R-1. Test Information Index (U), Issue 13, HQDNA 119M-13 (DTL 800312), Defense Nuclear Agency, 198 pp., 15 November 1979. (SRD-CNWDI)

R-2. DOD Nuclear Weapons Effects Tests Summary (U), Issue No. 17 (U), DNA 625D, Defense Nuclear Agency, 1984 review draft. (SRD-CNWDI)

R-3. Underground Test Experiment Catalog (U), DNA 2941F-series, Defense Nuclear Agency:

Volume I: Diesel Train, Diana Mist, Mint Leaf, Hudson Moon (U), DNA 2941F-1 (AD 523743L), by R.D. Schappaugh of Nuclear Defense Research Corporation of New Mexico, Inc. for DNA, 238 pp., September 1972. (SRD)

Volume II: (classified title), DNA 2941F-2, by R.D. Schappaugh of NDRC, Inc. for DNA, 380 pp., 15 August 1973. (SRD-CNWDI)

Volume III: Midi Mist, Dorsal Fin, Dido Queen, Husky Ace (U), DNA 2941F-3, by R.D. Schappaugh of NDRC, Inc. for DNA, 224 pp., 26 February 1974. (SRD-CNWDI)

Volume IV: Husky Ace, Ming Blade, and Dining Car (U), DNA 2941F-4, by J.A. Doran of General Electric Tempo for DNA, 134 pp., 5 November 1976. (SRD-CNWDI)

Volume V: Ming Blade, Dining Car, Husky Pup, and Mighty Epic (U), DNA 2941F-5, by T. Kostigen of General Electric Tempo for DNA, 146 pp., 30 June 1979. (SRD-CNWDI)

Volume VI: Husky Pup and Mighty Epic (U), DNA 2941F-6 (AD C034689), by K. Gould of Kaman Tempo for DNA, 66 pp., 30 July 1980. (SRD)

R-4. Nuclear Weapons Effects Computer Code Catalog (U), DNA 4614F, by M.W. McKay and W.J. Ozeroff of JAYCOR for DNA, 318 pp., 1 July 1978. (C)

Supplement 1 (U), by M.J. Dudash of Kaman Tempo, DASIAC, for DNA, 22 pp., 1 July 1980. (C)

R-5. Glossary of Terms - Nuclear Weapon Phenomena and Effects, DASIAC SR 84-2, by K.E. Gould of Kaman Tempo, DASIAC, for DNA, 171 pp., October 1984 review draft. (U)

R-6. Index of Nuclear Weapon Effects Simulators, DNA-IR-83-11 (AD B083135L), M.T. Toole, et al., DNA, 142 pp., 1 June 1983. (U)

APPENDIX

ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission (now DOE)
APACHE	Assessment of Pacific Communications for Hardening to Electromagnetic Pulse-EMP (program)
AWRE	Atomic Weapons Research Establishment (Britain)
BMD	ballistic missile defense
C ³	command, control and communications
CROM	customized read only memory, also continuous read only memory
DARCOM	U.S. Army Material Development and Readiness Command
DASA	Defense Atomic Support Agency (now DNA)
DASIAC	DOD Nuclear Information and Analysis Center
DELFIIC	Defense Land Fallout Interpretative Code
DNA	Defense Nuclear Agency (formerly DASA)
DOB	depth-of-burst
DOD	Department of Defense
DOE	Department of Energy
DTIC	Defense Technical Information Center
EMP	electromagnetic pulse
FEMA	Federal Emergency Management Agency
HE	high-explosive
HEART	Hydrometer Erosion and Recession Test (program)
HEMP	high-altitude electromagnetic pulse
HF	high frequency
HOB	height-of-burst

IEEE	Institute of Electrical and Electronics Engineers
IR	infrared
LF	low frequency
MHDEMP	magnetohydrodynamic electromagnetic pulse
NORSE	Nuclear Optical and Radar Systems Effects (Code)
NWP	Naval Warfare Publication
PEP	propellants, explosives and pyrotechnics
ROSCOE	Radar and Optical Systems Code
SGEMP	system generated electromagnetic pulse
TNF	theater nuclear forces
TNFS ^{2,3} _C	theater nuclear forces survivability and security [issues of] command, communications, and control (program)
TNW	theater nuclear warfare, or theater nuclear weapons
TNWC ³	theater nuclear weapons command, control and communications (program)
TREE	transient radiation effects on electronics
VLF	very low frequency

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